SCIENTIFIC AMERICAN

No. SUPPLEMENT 749

Scientific American Supplement, Vol. XXIX. No. 749. Scientific American, established 1845.

NEW YORK, MAY 10, 1890.

Scientific American Supplement, $5 a year. Scientific American and Supplement, $7 a year.

NEW EXPRESS ENGINE FOR ITALIAN MEDITERRANEAN RAILWAY.

THE necessity for fast trains between Rome and Turin, and between Rome and Milan, has induced the Mediterranean Company to get out an express engine in fact as well as in name, which was made last year at the new works just outside Turin, and was shown at the Paris exhibition with the fast goods engine lately illustrated.

The express engine, a perspective view of which is given, is capable of drawing a train of 160 tons on the level at a speed of 80 kiloms.—or 50 miles—an hour, or a train of 120 tons on a gradient of 1 in 100 at 50 kiloms., or 31 miles an hour. The weight, light, is 43 tons, and in running order 46·9 tons, thus distributed: On bogie, 17·4 tons; on driving axle, 14·7 tons; and on coupled trailing axle, 14·8 tons.

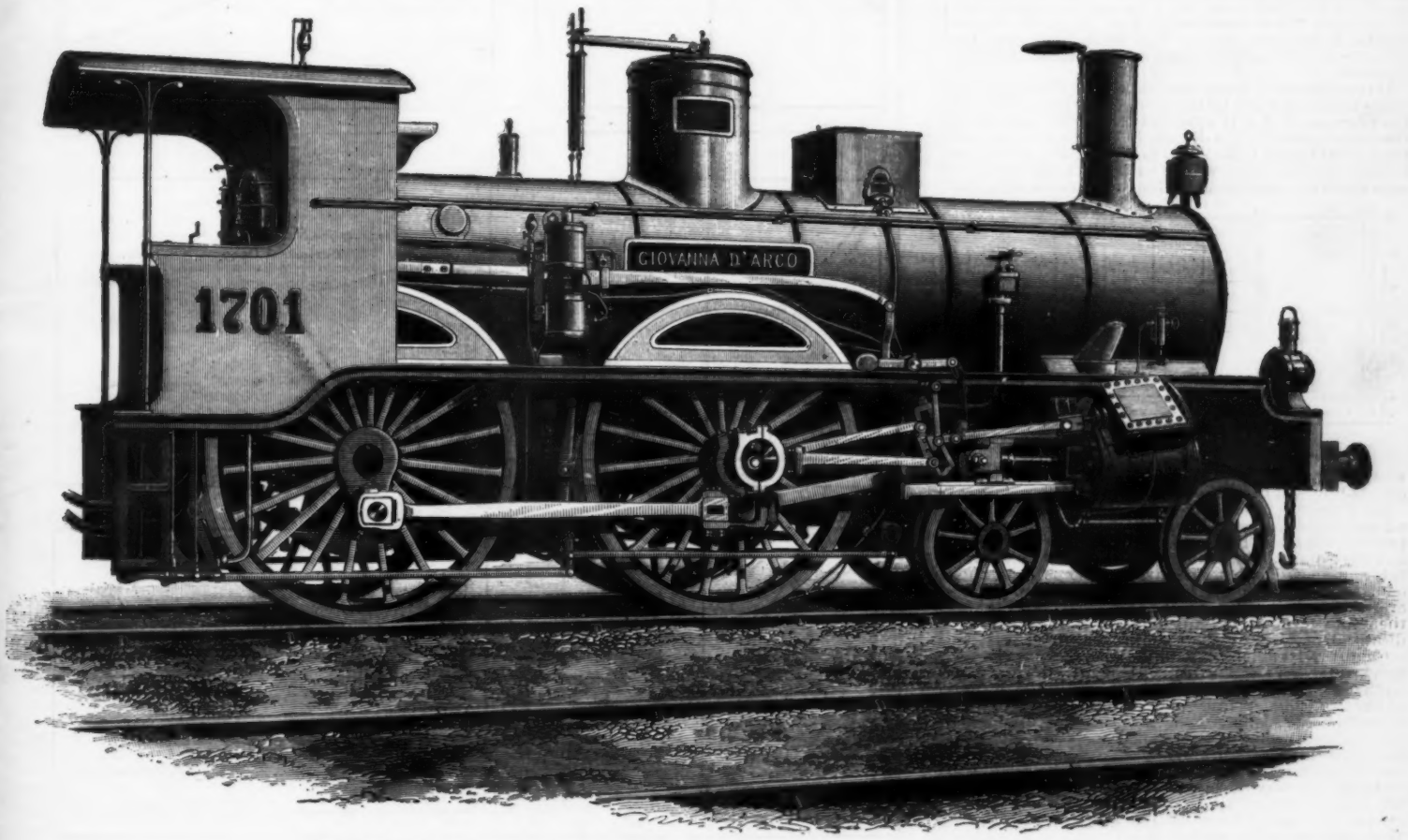
The fire box is on the Belpaire system. Although the roof is arched, it is tied to the copper box by straight wrought iron stays, and strengthened transversely by wrought iron tie rods. The cover of the dome, which is riveted to the hinder of the two boiler rings, carries a pair of safety valves with spring balances, while another valve, double, with direct acting springs, over the fire box, is locked, but provided with a lever. The nominal pressure is ten atmospheres, or 150 lb. The fire box, with inclined grate, over the trailing axle—as seen by the longitudinal section—is provided with fire-dropping gear, worked from the foot plate, as also are the front and back doors of the closed ash pan.

The frame consists of two longitudinal plates, 28 mm. or 1⅛ in. thick, braced together by several cross ties. Those below the smoke box carry the cap of the bogie pin, the top of which is hemispherical. The bogie frame is a rectangular box, formed by its longitudinal plates being connected by cross stays, and in the middle of which the cast steel bogie pin is riveted. The cast iron cap is connected with the main frame by a system of links, which permit of lateral displacement to the extent of 20 mm., or ¾ inch., in addition to the play of 7½ mm., or $\frac{5}{16}$ in., between the axle journals and their bearings. As in the Bissel bogie, however, the tendency after displacement is for the bogie to resume its normal position. This arrangement permits of the engine running easily round curves of less than 300 meters, or 328 yards, radius, of which there are a great many between Genoa and Pisa. In addition to the central pin, the bogie rests on two side brackets carried by volute springs, each offering a resistance of 2¼ tons. The links of the inverted bearing springs are provided with India rubber washers. The steel tires are attached by safety rings to the wheels, both pairs of which are provided with counterweights, designed expressly to counteract the horizontal as well as the vertical disturbances of the parts in motion.

The slide valve makes an angle of 45 deg. in a vertical transverse plane with the horizontal plane of the cylinders, being outside and slightly inclined in a vertical longitudinal plane. The valve gear on Gooch's system, with screw reversing gear, is entirely outside, for facility of inspection and cleaning, because the running sheds are not all provided with pits, and the ballast on many parts of the line is very friable. The slide valve, although symmetrical, is arranged so as to give unequal lap, with a view to counteract the disturbances caused in the phases of steam distribution by the angle of the piston, connecting rod, etc., and thus equalize as much as possible the action of the steam on both sides of the piston. The slide valve is cast of gun metal, and has an internal passage on the Trick system, affording additional sectional area for the first admission of steam.

The engine is fitted with an air compressor for the Westinghouse continuous brake, with the Gresham apparatus for projecting sand under the driving wheels by a steam jet, with two Friedmann injectors, and with Chatelier's arrangement for the cylinders to draw in water from the boiler while the engine is running down hill without steam. The blast pipe orifice, besides being surrounded with a perforated ring for blowing the fire before starting, has a valve for reducing its sectional area. The chimney, which is carried by a cast iron seating, is slightly tapered inward from top to bottom, and terminates in an inverted hollow cone for receiving the blast. The principal dimensions and particulars are as follows:

Grate—		
Length	2·35 m.	= 7 ft. 8½ in.
Width	0·98 m.	= 3 ft. 2⅝ in.
Area	2·3 sq. m.	= 25 sq. ft.
Fire box—		
Length, outside	2·344 m.	= 7 ft. 8 in.
Outside width at bottom	1·012 m.	= 3 ft. 4 in.
Outside width at top	1·097 m.	= 3 ft. 7 in.
Mean height, grate to roof	1·24 m.	= 4 ft. 1 in.
Thickness of copper sides	16 mm.	= ⅝ in.
Thickness of copper roof	20 mm.	= ¹³⁄₁₆ in.
Boiler—		
Length	4·928 m.	= 16 ft.
Diameter	1·31 m.	= 4 ft. 4 in.
Thickness of plates	15 mm.	= ⅝ in.
Center line above rail	2·3 m.	= 7 ft. 7 in.
Thickness of copper tube plate	28 mm.	= 1⅛ in.
Thickness of iron tube plate	25 mm.	= 1 in.
Tubes—		
Number	170	
Diameter, outside	50 mm.	= 1⅞ in.
Diameter, inside	44 mm.	= 1¾ in.
Length between tube plates	3·8 m.	= 3 ft. 6 in.
Capacity—		
Water space	3·8 cu. m.	= 134 cu. ft.
Mean space	9·1 cu. m.	= 74⅓ cu. ft.
Heating surface—		
Fire box	10 sq. m.	= 107⅝ sq. ft.
Tube (outside)	101 sq. m.	= 1086¾ sq. ft.
Total	111 sq. m.	= 1194⅓ sq. ft.
Cylinders—		
Diameter	0·45 m.	= 18 in.
Stroke	0·62 m.	= 2 ft. ¼ in.
Between center lines	1·93 m.	= 6 ft. 4 in.
Motion—		
Length of connecting rod	1·955 m.	= 6 ft. 5 in.
Throw of eccentric	60 mm.	= 2⅜ in
Wheels—		
Diameter of coupled	2·1 m.	= 6 ft. 11 in.
Diameter of bogie	0·974 m.	= 3 ft. 2 in.
Rigid wheel base	2·600 m.	= 8 ft. 6 in.
Total wheel base	6·800 m.	= 22 ft. 4 in.
Axle journals.		
Of coupled wheels, diameter	0·19 m.	= 7½ in.
Of coupled wheels, length	0·23 m.	= 9⅛ in.
Of bogie, diameter	0·14 m.	= 5½ in.
Of bogie, length	0·24 m.	= 9½ in.
Tires—		
Thickness	0·065 m.	= 2⅝ in.
Frame—		
Total length	9·75 m.	= 32 ft.
Between plates	1·23 m.	= 4 ft. 1 in.



EXPRESS ENGINE, ITALIAN MEDITERRANEAN RAILWAY

The six-wheeled tender, with axle boxes outside the wheels, holds 2,200 gallons of water and 3½ tons of coal. The weight empty is 14 tons, and loaded 28½ tons. —*The Engineer.*

[THE RAILWAY MASTER MECHANIC.]

STEAM DISTRIBUTION IN COMPOUND LOCOMOTIVES.

BUFFALO, N. Y., Feb. 20, 1890.

To the Editor of the Railway Master Mechanic:

Possibly there are some among your readers who are desirous of becoming better acquainted with the subject "Steam Distribution in Compound Engines," but who are impeded in their attempts to obtain even a theoretical knowledge of it by the absence of any collection of reliable data.

Something can be learned by the construction of imaginary indicator diagrams, assuming different proportions of cylinders, etc., and using the isothermal expansion line, which is easily drawn, and gives a sufficiently correct idea of steam distribution. For the benefit of those who are not familiar with the method of drawing this line, the following diagram and explanation are appended.

It is a well-known fact that if a certain quantity of any gas be maintained at a uniform temperature, its pressure will depend upon its volume. If it be allowed to expand to twice its volume, it will have but one-half its original pressure. If it be compressed to one-half of its original volume, its pressure will be dou-

bled, the one change being exactly proportional to the other. Upon this law the construction of the isothermal (equal temperature) line is based.

In Fig. 1 let A B be supposed to represent the length of stroke of a steam engine, and A H the cylinder clearance. D H, which forms one end of the diagram, is scaled to pounds pressure, and V I, the vacuum line, is drawn at a distance of 15 pounds, by the scale on D H, below A B (the line of atmospheric pressure), and parallel to it.

At V there is neither pressure nor volume. Along the line, V I, there is volume but no pressure. On V D there is pressure but no volume. Any point taken in the space above V I and to the right of V D will denote a certain pressure and a certain volume according to its position. D F is assumed to be the line of steam admission, and C the point of cut-off. C K is drawn perpendicular to A B, and diagonals are drawn from V to points taken at random on the line C F, cutting the line C K.

Only so much of these lines are shown in Fig. 1 as will define their intersections with C K and C F. Perpendicular and horizontal lines are drawn from these points of intersection, and the curve, C T, is drawn through the meeting points.

This is the isothermal line, which would be the correct curve for denoting the rate of expansion of a gas if it did not change in temperature during its expansion.

As there is always a reduction of temperature during the process, the true theoretical or adiabatic line falls a little below the isothermal at T.

The exhaust port opens as the piston nears the termination of its stroke, and the steam escapes. This is shown by the curve, X B. The length of the line, T I, denotes the terminal pressure, and is the measure of the steam used for one stroke. It is taken in terms of absolute pressure, as it is called, being measured from the vacuum line, not the atmospheric.

The exhaust port closing as the piston reaches the point, N, on the return stroke, a certain quantity of steam is retained in the cylinder and is subject to compression as the piston finishes its movement from N to A. If we draw the diagonal, V O, through the point, A, and erect the perpendicular line, N O, its length applied to the scale on the line, D H, will give the pressure in the clearance space at the termination of the stroke.

If it is desired to know how much of the clearance space would be filled by the volume of steam, H A, at the pressure, N O, if it were still further compressed to the initial pressure, the diagonal, V E, is drawn, and the lines O U and U R. That is to say, the steam retained by compression will be sufficient to fill the clearance space at initial pressure for the distance, D R, and

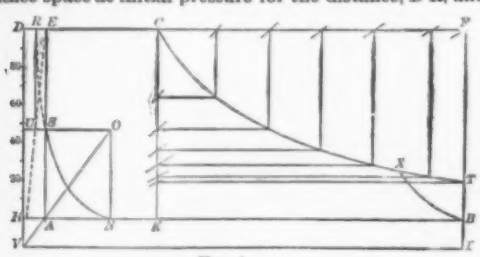


FIG. 1.

when the valve opens, the volume of steam admitted is denoted by R C instead of D C.

No allowance is here made for wire drawing during admission or for back pressure during exhaust. In practice the steam line would drop during admission, and the exhaust line would be somewhat higher than it is represented. These points, with some others, are omitted, to avoid complication and confusion. There are some lessons which can be learned without taking them into account, and any one conversant with indicator diagrams can make the proper allowance.

Compound engines are built in various ways. In some the steam passes directly from the high pressure to the low pressure cylinder. In this case the pistons of the two cylinders must move simultaneously. Sometimes they are so built that the steam is discharged into an intermediate vessel called a "receiver," as it leaves the high pressure cylinder, passing from it to the low pressure cylinder. In this form the pistons of the cylinders may move together or at different times, the two engines working in the latter case on separate cranks, which may be set 90° apart, as with the locomotive, or at any other angle.

One form of marine engine has one high pressure and two low pressure cylinders, working three cranks set 120° apart. This form of engine gives a very smooth, steady motion.

In the locomotive the simplest arrangement for compounding consists in the use of a large cylinder on one side, a small one on the other, and operating cranks set at right angles, as usual.

A receiver is a necessity in this case, as the high pressure cylinder exhausts its steam while the valve of the low pressure cylinder is closed, and a reservoir must be provided to retain the steam during the interval of time between the time of exhaust of one cylinder and the time of admission of the other.

The receiver in the locomotive usually consists of a large copper pipe passing around the interior of the smoke box. The steam it receives is always wet, and is dried to some extent during its passage through it by its exposure to the hot gases of the smoke box. It would seem that if the receiver were made up of a number of small pipes, so as to present a greater surface for the absorption of heat, with the same sectional area for the passage of the steam, that it would be advantageous, for the heat of the smoke box gases is an unmitigated waste, and any portion of it which can be retrieved and converted into work is a clear gain

For the purpose of illustration we will suppose an engine with a receiver, the two pistons having the same time of movement, and we will proceed to construct diagrams at various points of cut-off, and observe the peculiarities of steam distribution.

We will suppose the engine to be proportioned as follows:

Ratio of high to low pressure cylinder, 1 to 2½.

Receiver equal in capacity to high pressure cylinder.

Clearance in either cylinder, 10 per cent.

Slide valves cutting off by their own lap, with neither lap nor clearance on the exhaust side.

According to these data, Figs. 2, 3, and 4 have been drawn. In each of these figures the cut-off point of the high pressure cylinder is the same, 80 per cent. The cut-off point of the low pressure cylinder is in Fig. 2 = R L, and the cut-off point, B, established. Letting fall a perpendicular line from A, a diagonal is drawn from U to B, cutting it at C.

This is supposed to be indicative of the pressure at the time of cut-off in the low pressure cylinder, the pressure being the same for the instant in the other cylinder and the receiver. The line, D E, is drawn in the receiver space, at the height of the point, C, denot-

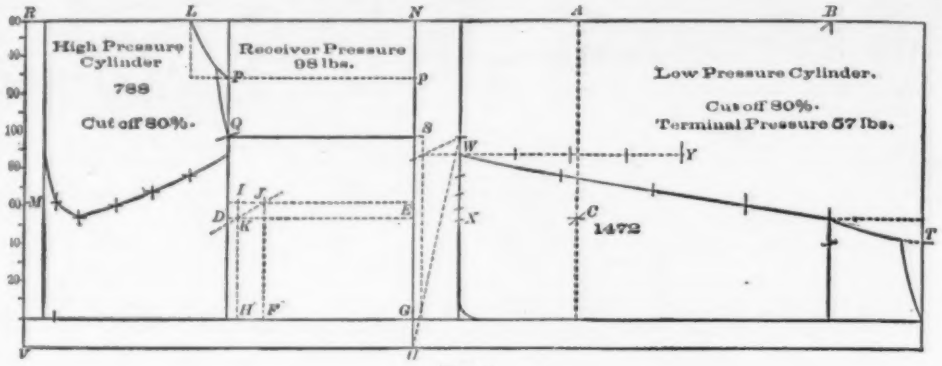


FIG. 2.

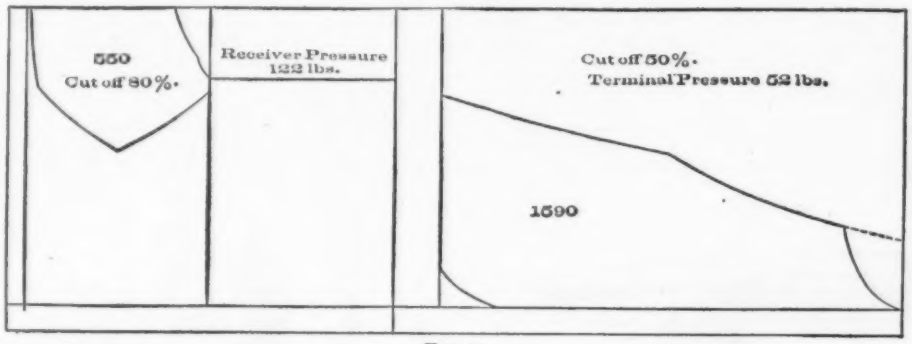


FIG. 3.

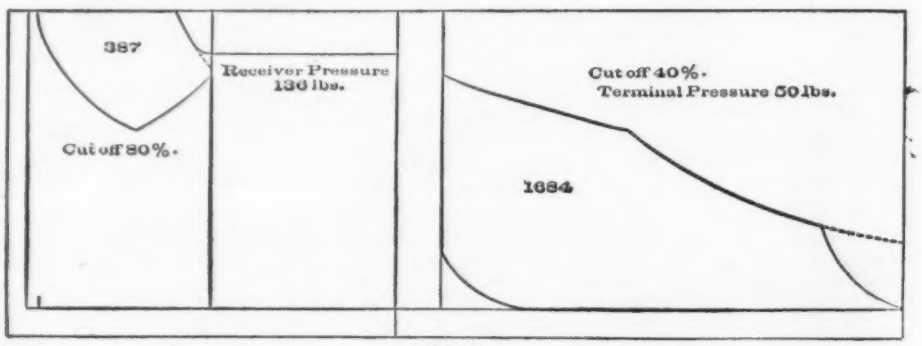


FIG. 4.

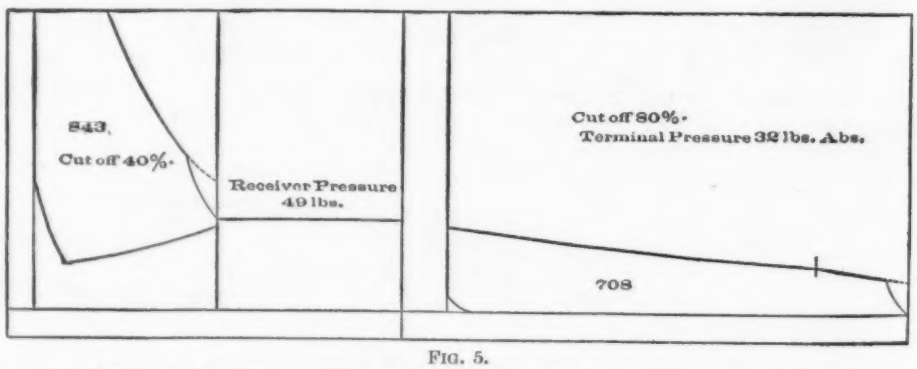


FIG. 5.

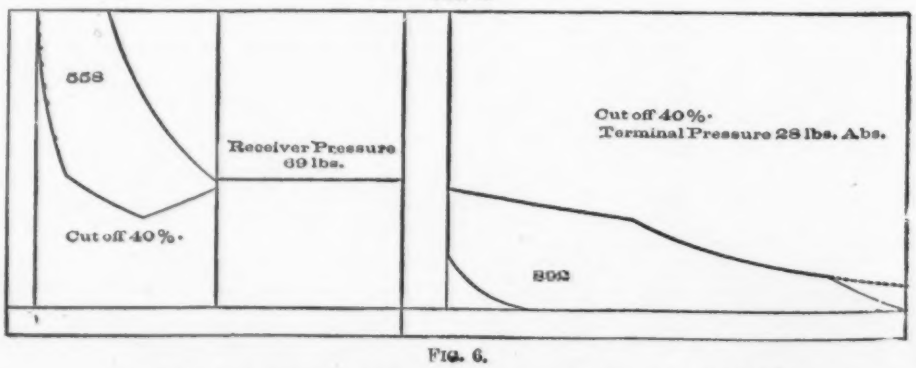


FIG. 6.

STEAM DISTRIBUTION IN COMPOUND ENGINES.

80 per cent., in Fig. 3, 50 per cent., and in Fig. 4, 40 per cent.

In order to show the respective volumes of the two cylinders, the diagrams are drawn as though the cylinder area was the same, the difference being in the length of the stroke.

The cut-off point of the high pressure cylinder being set off, the expansion curve is drawn (Fig. 2). On the upper line of the low pressure diagram, A N is set off, ing that the receiver is filled with a volume of steam of the pressure, C.

As the piston has not finished its stroke, steam is compressed into the receiver from the high pressure cylinder until its exhaust port is closed. For convenience the high pressure piston movement is laid off in the receiver space. T G represents the distance traveled up to time of low pressure cut-off, and F H the distance it travels up to time of closure of exhaust port.

To find the increase of pressure in receiver, erect perpendiculars, H I, F J, and draw diagonal from V through K. The intersection, J, gives the desired pressure. A horizontal line through J, if carried to the scale line, R V, would cut it just above 60 pounds. A check, M, is made at this point.

A cylinderful of high pressure steam is now exhausted into the receiver, and it is required to know the resultant pressure. A horizontal line drawn from the point of terminal pressure, P, will cut the line, N G, at P, and a diagonal from M to P will cut P D at Q. This is the new receiver pressure.

The steam retained in the clearance space of the low pressure cylinder brought to receiver pressure and added to the volume increases it to S. When the steam is admitted to the low pressure cylinder, its pressure drops to W in filling the clearance space.

The stroke of the low pressure piston now begins, and the high pressure piston begins its return stroke. One allows expansion, the other produces compression. To ascertain the net increase of volume, the movement of one piston must be subtracted from that of the other. It is represented by the line W Y. If the point, C, was correctly assumed, a diagonal drawn from V to Y will cut the perpendicular line W at X, on the same level as C. If it does not, the point, C, must be changed, and the process above described repeated. Being assured that the line, W Y, is correctly placed, it is divided into a number of equal parts, and diagonals drawn from V, cutting W X.

The travel of the low pressure piston to the cut-off point is divided into the same number of equal parts, and cross marks made from them and the diagonals. Through these the steam admission line is drawn. The expansion line is located by diagonals from U, cutting a perpendicular let fall from B, and a steam line on a level with C.

The exhaust line of the high pressure diagram is next laid out from the points between W and X. The compression line is so short in Fig. 2 that it can be drawn by hand. When it is longer, it can be laid out by drawing diagonals from V to spaces in the line, I J. Their intersections with I K will locate the compression line by transferring the spacing of I J to the compression space.

The figures upon the diagrams denote their proportionate area. A considerable drop in pressure is observable between the two cylinders in Fig. 2, the terminal high pressure being 130 pounds, the initial low pressure 88 pounds. This loss is not regained, and the effect produced is less than if the pressures were kept together, as will be seen later on.

Figs. 3 and 4 show the effect of an earlier cut-off upon the low pressure cylinder. In Fig. 4 the receiver pressure is even higher than the high pressure terminal, dropping so as to agree with it when the valve opens and allows the low pressure clearance space to be filled. Comparison of the three sets of diagrams illustrates how shortening the cut-off of the low pressure side increases, instead of diminishing, the amount of work done by it. Between Figs. 2 and 4 the area of the high pressure diagram is diminished by half. The excessive compression in Fig. 4 will also be noted.

In Fig. 5, the high pressure clearance is 15 per cent., the high pressure cut-off 40 per cent., and the low pressure cut-off 80 per cent. Here there is again a considerable amount of "drop" between the two cylinders. The high pressure diagram is much larger than the low pressure.

In Fig. 6, the cut-off in each cylinder is 40 per cent. The terminal pressure of one cylinder and the initial pressure of the other approximate closely. The greater part of the work is thrown, however, on to the low pressure cylinder. It would appear, then, that when there are two reversed levers, so that the cylinders can be handled separately, hooking back either lever increases the proportional amount of work done by its cylinder, and there is a strong probability that an engine can be so proportioned that both sides can be operated by means of a single reverse lever, and a close equality in the work done by the respective cylinders preserved for all points of cut-off.

Comparing Figs. 2 and 5, we see that shortening the high pressure cut-off has not materially affected the amount of work done by that cylinder, but the area of the low pressure diagram No. 5 is less than one-half that of No. 2.

A comparison of Figs. 2 and 6 will give an idea of what may be expected if only one reverse lever is used. It will be seen that the low pressure cylinder leads in the amount of work done, in both diagrams, and the proportion is nearly the same between the high and low pressure cards in both cases.

It is fair to suppose that the single reverse lever would answer a good purpose for points of cut-off between those shown, but for shorter ones there would be excessive compression in the high pressure cylinder unless the clearance were made still greater.

In Figs. 2, 3, and 4, and again in Figs. 5 and 6, the point of high pressure cut-off being the same in each set, the terminal pressure of the low pressure cylinder varies but little. In fact, "hooking back" this cylinder appears to have but little effect, except to increase the proportion of work done by it, and to increase the back pressure of the other side.

If we now tabulate the areas and terminal pressures of the respective diagrams, we will be able to form some idea of their relative showing of economy in using steam. Roughly speaking, the areas of the cards may be taken to represent useful effect produced, and the terminal pressures, the cost of producing it.

	H. P. Cyl.	L. P. Cyl.	Total.	Terminal Pressures.
Fig. 2	788	1,472	2,260	57
Fig. 3	550	1,590	2,140	53
Fig. 4	387	1,686	2,073	50
Fig. 5	843	708	1,551	32
Fig. 6	558	892	1,450	28

(The terminal pressures are measured from the vacuum line.)

Dividing the totals by the terminal pressures, we get an idea of the relative economy. That is to say, one pound of steam at terminal pressure has produced in—

Fig. 2 an effect of	39·65
Fig. 3 " " "	41·15
Fig. 4 " " "	41·40
Fig. 5 " " "	48·47
Fig. 6 " " "	51·79

This shows the effect of "drop," or the loss of pressure between the cylinders. In these instances it amounts to about 5 per cent. There is almost always some loss of this kind, partly from friction of the steam in the passages.

Where is the gain from compounding? It cannot be shown in a diagram, but experience has demonstrated most conclusively that there is one of considerable amount. There is a slight gain in the manner in which the force of the steam is applied, which counts for something. If the whole force of 100 pounds of steam were applied to the low pressure piston, it is evident that a great strain would be brought upon the engine, much greater than when it is used successively in the two cylinders; and by the time the crank had passed far enough over the center to give the piston a good purchase upon it, steam would be cut off and the pressure would drop. So a great part of the force of the steam would be used in straining the machinery, not in producing any useful effect.

In Fig. 2 of the examples here shown, both cylinders, working at 80 per cent. cut-off, only use a quantity of steam which would constitute a 26 per cent. cut-off if used in the low pressure cylinder alone. It is well known that this is as short an admission as can be economically used in a single cylinder, and as short as can be produced by ordinary valve mechanism, unless a separate admission valve or a cut-off valve is resorted to.

The greatest gain is from the saving in cylinder condensation, a subject on which there is too much to be said to allow it to be touched upon at this time. What has been written here is only meant to suggest the way of working out the problems which occur in the study of the subject. Each different proportion of one cylinder to the other, or to the receiver, must be worked out by itself.

There is no denying the fact that the introduction of the principle of compounding into locomotive designs will effect a great reduction in the amount of fuel used, and that the compound locomotive is the locomotive of the future.

If we turn to marine practice, what do we find? History shows a steady increase in the steam pressures employed, and since the introduction of compounding, a steady progress, both in economy of fuel and in reduction of the weight of the machinery, as compared with the power produced.

In the '40s, 5 to 7 pounds was the usual pressure; by 1860 compound engines were in use at a pressure of 25 to 40 pounds; in the '70s, the pressure was 45 to 60 pounds, the average piston speed about 375 feet per minute, and the consumption of coal a little over two pounds per horse power per hour; by 1880–82 the pressure had risen to about 80 pounds, piston speed to 450–475 feet, and coal consumption had been reduced to 1·83 pounds per horse power hour.

Double cylinder compounds have been superseded by triple cylinders, and even four cylinder engines have been built.

Triple expansion engines are now in use with steam pressures as high as 165 pounds and piston speeds of 800 to 1,000 feet per minute, giving a fuel economy of 20 per cent., as compared with double expansion engines working at about 80 pounds pressure, and, say, half the above piston speed.

The combined weight of engine, boilers, and water in modern marine practice is much less than it was when the old single cylinder engines were in use. Triple expansion engines have been built which weigh—engine, boiler, and water—as low as 140 pounds per indicated horse power.

In view of these facts, is it not apparent that the subject of compounding locomotives is worthy of attention?

Respectfully yours,
GEO. B. SNOW.

THE INTER-CONTINENTAL RAILROAD.

SINCE the Pan-American Congress has recommended an inter-continental railroad, there has been considerable discussion of the subject. Very little has been said, however, of the probable—or possible—route through southern Mexico, Central America, and Colombia. I have seen it stated that a railroad through these countries is not feasible; but as an engineer, and one who has been over the ground, I wish to correct that impression. As there is a line now being constructed from the city of Mexico to Oaxaca, we can begin the discussion as to what is the best route from the latter city.

The route that presents the fewest difficulties, and the one that would cost the least, is from Oaxaca to Tehuantepec, and thence down the Pacific side of the Sierra Madres to Panama. This route is also the shortest, as will be seen by a glance at the map. Perhaps it would be as well, before going further, to give my reasons for claiming this to be the best route.

To begin with, the backbone of the continent is very much nearer the Pacific than the Atlantic coast. On the Atlantic side the country intervening between the mountains and the level plain of the coast is cut up into tablelands of different elevations, and crossed by many deep canons and *barrancas*. There are also many spurs from the mother range that would make the line more difficult of construction. But the main objection to a route on this side has yet to come, viz., the peninsula of Yucatan.

To follow the coast line would, of course, greatly increase the distance, and any attempt to cut across the head of the peninsula would throw the line into the mountains of Guatemala, about as rough a country as there is on the continent (see map). The mountains of Guatemala and Spanish Honduras reach to the Atlantic coast, being a continuation of spurs from the main range, and no railroad could be built through them without very great expense. The route on the Pacific side is not only the shortest, but would pass through more important towns and cities than any other route.

Want of space will not permit me to go into the resources of the country, so I will content myself with stating that the Pacific coast is the most developed. Oaxaca is a city of 30,000 inhabitants, situated in a very fertile mountain valley. Between this city and Tehuantepec is a very rough, broken, and mountainous country, which will be the most difficult and expensive part of the line to build. This is the only barren and unproductive part of the whole route, but there is mineral to be found everywhere, and in several places I saw signs of coal. There is timber enough for construction, plenty of scrub oak for ties, and on the higher mountains good pine. While pounding over this country on a mule I have wished more than once that the Pan-American Congress had been held years ago.

MAP SHOWING A ROUTE FOR THE PROPOSED INTER-CONTINENTAL RAILROAD.

Tehuantepec is a city of 15,000 inhabitants, mostly Indians, and is located about fifteen miles from the port of Salina Cruz. The Tehuantepec Railroad has been completed from the port to the city, and some little distance beyond; and there have also been some twenty miles of rails put down on the Atlantic side from Minatitlan. There has been money enough sunk here to build twenty such roads, but it is no nearer completion than it was ten years ago.

From Tehuantepec to the border of Central America, and in fact to Panama, there will be found no engineering difficulties. Leaving Tehuantepec, the proposed road would follow the coast line at a distance of from 20 to 30 miles from the beach, where the ground is high enough to preclude all danger of inundation, and not near enough the mountains to be broken up into foothills.

Within the limits above mentioned the grading will not amount to much, as it is a level plain, reaching clear across the state of Chiapas and into Guatemala. To locate the line nearer the coast would throw it into the swamps, and to go nearer the mountains would mean heavier work and rock cuts. The most expensive items of construction here will be clearing and bridging, for it is a very heavily timbered country, and there are numerous small streams. The timber is good, there being plenty of Spanish cedar and several varieties of mahogany. The rubber tree is also plentiful. Labor is scarce and not particularly good; that is, some of it. Any attempt to work it by the day will result in loss of money and temper. Everything is done by task work, and if this system is used from the start, it will do away with a great deal of annoyance.

Tonala, a city of 12,000 inhabitants, and Tapachula, a place of six or eight thousand, are the only towns of any importance in the state of Chiapas reached by this route. Both of these places are situated some little distance inland, but each has its own port. Chiapas is an almost unknown and undeveloped state, but, like the Central American republics, will grow almost anything. Between the lowlands of the coast and the higher mountains, one can get any climate desired. I have known the Indians to grow three crops of corn in a year on the coast. On the foot hills is good coffee land. Just over the line in Guatemala is raised some of the finest coffee in the world; so good, in fact, that you will not see it quoted in the market, because it is all sold as Mocha. The only means of com-

munication at present with the outside world is by the Pacific Mail Steamship Company. I would not for the world say anything against this company, but if one has plenty of time, he can make good money by walking.

Crossing the line into Guatemala we reach Retaluleu, a place of 8,000 inhabitants, and the center of a large and rapidly increasing coffee district. This town has a railroad to the coast, a distance of 26 miles, and surveys have been made to Quesaltenango, a city of 30,000 inhabitants, about 50 miles from Retaluleu. The general character of the country is the same as in Mexico, except that the mountains rise more abruptly, and in many places the soil is covered with a layer of volcanic ashes. The only rivers of any size in Guatemala to be crossed are the Waranjo, Michatoya, and the Rio de los Esclavos.

At Escuintla we connect with the Guatemala Central Railroad. This is a road 71 miles in length, connecting the capital at the coast with San Jose. Work was begun on the Northern Railroad, which was to reach from the Atlantic coast to Guatemala City, a distance of 225 miles, but the untimely death of General Barrios put a stop to all construction. If the inter-continental road is started, this road will undoubtedly be finished. Guatemala exports annually 800,000 cwt. of coffee, mostly to Hamburg and London. Nearly all the coffee is grown on the Pacific slope, and is shipped to Europe via Panama. There are thousands of acres of good coffee land not yet cleared.

From Escuintla to San Salvador, the capital of the republic of the same name, the country is rather more broken. Beginning at Acajutla, the character of the coast is changed, and instead of being low and sandy, is abrupt and rocky. This continues into Nicaragua. There is plenty of limestone here, and it makes the finest lime I have ever seen. The Lempa is the only river of any note to be crossed in San Salvador. From Acajutla there is a short piece of railroad running to Sonsonate. The capital is the objective point of this road. San Salvador ships considerable coffee and sugar—all to Europe. A railroad is projected across Honduras from ocean to ocean, and a short piece is now in operation on the Atlantic side, from Puerto Cortez to San Pedro.

After leaving San Salvador and heading the Gulf of Fonseca, the first place of any note is Leon, in Nicaragua. This city is connected by rail with the port of Corinto. This part of the country is thickly studded with volcanoes, and lava is found everywhere. There is little or no rock, and stone for construction will not be over plentiful.

Let me warn contractors who are new to these countries to look sharp to their classification. There is a great deal of volcanic ashes in different layers, and some of it is very hard. This is classified as *tosca*—at about loose rock prices. Some engineers give hard and soft *tosca*. It makes very fair ballast when gravel cannot be obtained. There is plenty of timber here; in fact, the whole route is heavily timbered from Tehuantepec to Panama.

From Leon the route skirts the lakes Managua and Nicaragua, passing through the cities of Managua and Granada—these two places are already connected by rail. Nicaragua is the poorest of all the Central American republics, not raising much of anything but fleas. A branch line into the northeastern part of the republic would open up an entirely unknown country.

In Costa Rica the mountain range becomes more defined, but the route has only to hug the foot hills to find level ground. The railroad from Port Limon across the continent to Punta Arenas will soon be completed. There are now three pieces of this road in operation: one from Port Limon to the mountains, one from San Jose toward the Pacific coast, and one from Punta Arenas to Barranca. Construction is now being pushed on the remainder.

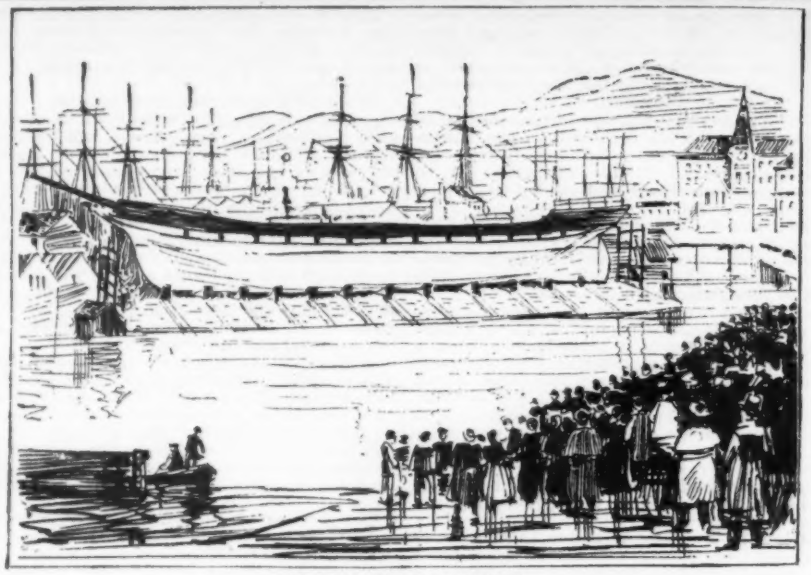
Through Colombia the route must of necessity be nearer the coast, as the continent is getting narrow and the mountains take all the room. There will be found here a few rocky spurs reaching to the coast. From Panama it is a simple matter to connect with Cartagena. Much has already been written of a route from the latter city to connect with the railroad systems of South America, and besides it is time I was drawing my long letter to a close.

One word about the climate. I have lived several years in tropical America, and never suffered as much from the heat as I have in New York City. Sunstrokes are unknown, and the much dreaded fever generally visits those who have made up their minds that they must have it anyhow. The high death rate of Panama is due more to bad whisky than to any other cause.

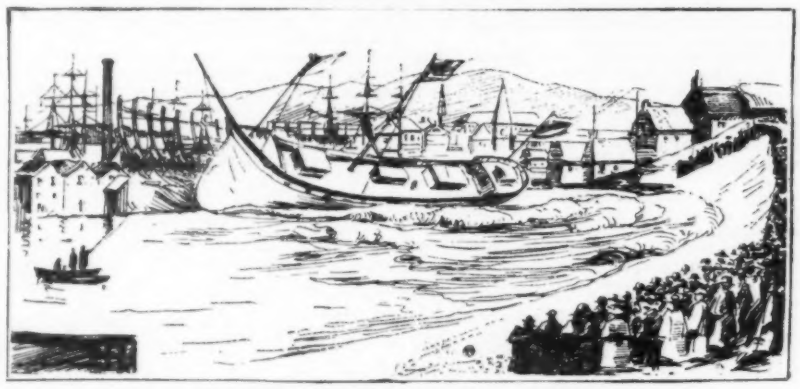
I have been over nearly all of the route herein described, and have endeavored to give a plain statement of facts. It is merely a question of time until such a road will be built, and, in my opinion, it cannot be commenced too soon.—*F. W. C. in the Railroad Gazette.*

A BROADSIDE LAUNCH.

An event which had long been looked forward to in shipping circles recently took place at Maryport. The yard of Messrs. Ritson, the principal shipbuilders in the town, is on the banks of the River Ellen, which at this point is not more than thirty yards across. At one time the ships built by the firm in question were launched in the usual manner, stern first; but some years ago a daring spirit suggested that they should be pitched into the water, as it were, broadside on. The experiment, the first of its kind in England, was tried on a very small ship. The result was awaited by those principally concerned with fear and trembling. Fortunately the venture proved a perfect success. Since then, Messrs. Ritson have gradually increased the size of the ships launched from their yard in this peculiar fashion; and on March 22 they threw into the water—there is no other term for it—the largest ship, with the exception of the Great Eastern, that has ever been launched broadside on. Many thousands of persons traveled from all parts of the country to witness this novel launch. The ship is built of steel, and in due course will be fitted with four masts. She is 289 feet in length, and thirty-nine feet in depth, with a displacement of 3,200 tons. The launch took place soon after midday on March 22, but long before that hour thousands of people occupied every coign of vantage on the Moat Hill, which overlooks the docks and ship yards, of which the inhabitants of the flourishing town of Maryport are so proud. For fully half an hour before the launch nothing was heard but the dull thud of the workmen's sledge hammers. Then the "trigger"—the only thing which kept the ship in her cradle—was knocked away, and the huge mass of metal fell over a low wall into the river.—*Daily Graphic.*



BEFORE THE LAUNCH.

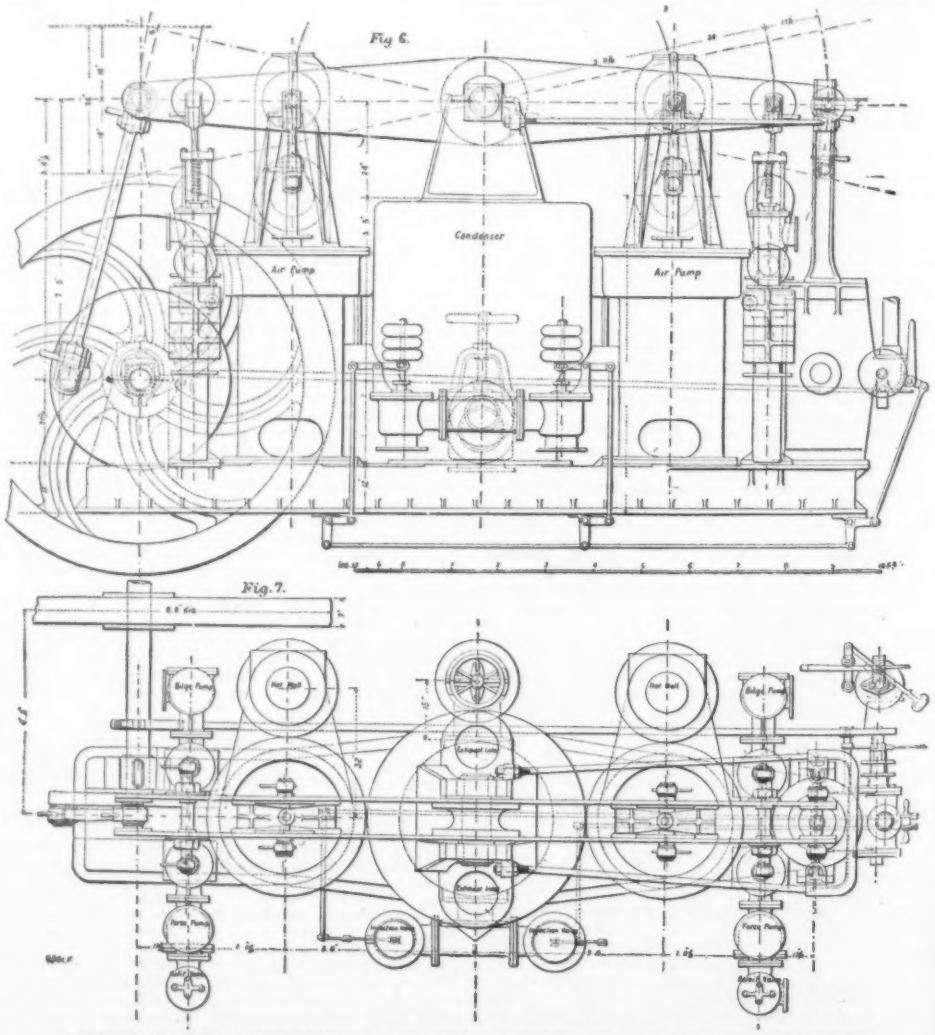


THE VESSEL TAKING THE WATER.

LAUNCH OF A SHIP BROADSIDE ON.

THE FERRY STEAMER TRANSFER.

The Transfer is designed to carry the cars of the Canada Southern Railway on to the Michigan Central line, and for that purpose is equipped with three lines of rails on the deck, these rails being capable of accommodating twenty-one of the longest eight-wheel



AUXILIARY ENGINES OF THE FERRY BOAT TRANSFER.

THE FERRY BOAT "TRANSFER" OF THE CANADA SOUTHERN RAILROAD COMPANY.

CONSTRUCTED BY THE CLEVELAND SHIPBUILDING COMPANY, CLEVELAND, OHIO.

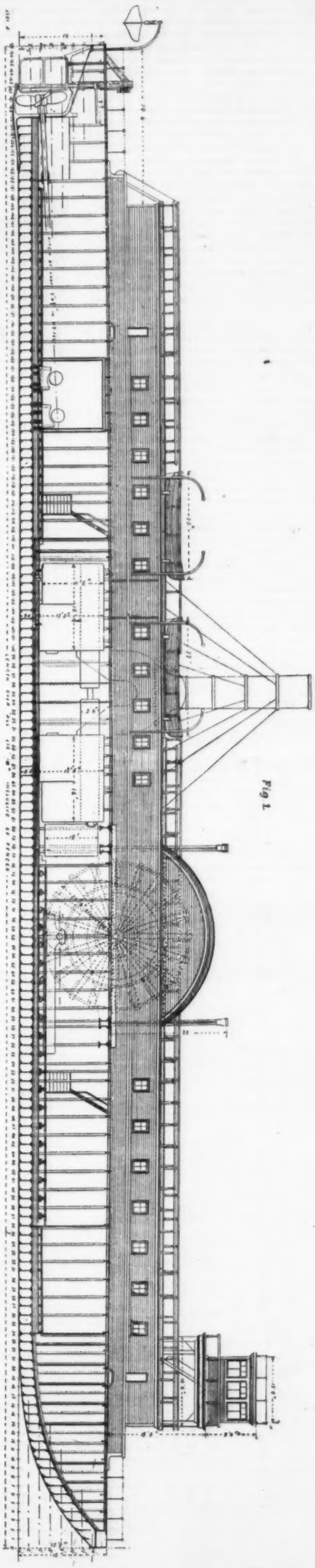


Fig. 1.

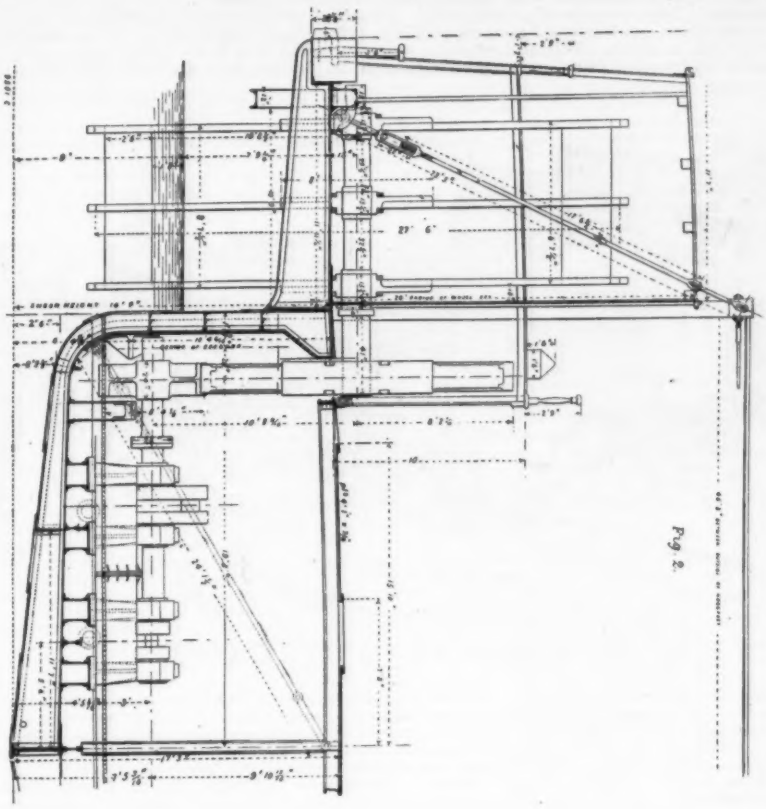


Fig. 2.

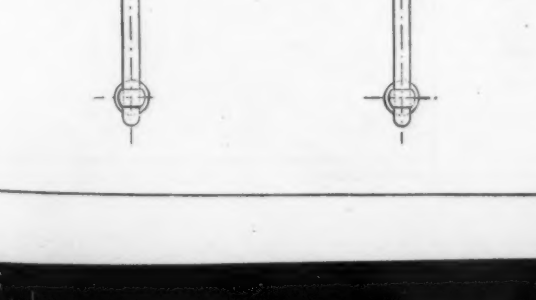


Fig. 4.

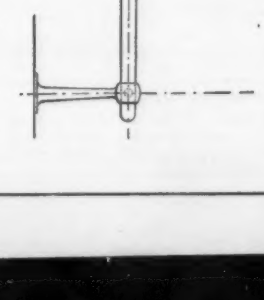


Fig. 3.

freight cars, or fifteen passenger cars, each 56 ft. long. The boat (Fig. 1) is 280 ft. long over all and 17 ft. 3 in. deep; the breadth of the hull is 45 ft., and the breadth over the guards 74 ft. 6 in. When light with coal on board she will draw 9 ft. forward and 10 ft. aft; with twenty-one loaded cars her draught will be about 11 ft. forward and 12 ft. aft. The Detroit River, through which the Transfer plies, is subject to serious accumulations of ice. To enable the boat to break her way through them, she is formed with an exceedingly heavy bow, having a vertical section like a sledge runner (Figs. 1 and 5), and strengthened by extra strong keelsons and additional bulkheads. Her powerful engines cause the bow to ride up on the ice, breaking it down and separating it to leave a lane for the passage of the vessel. To aid the ice breaking, the paddle wheels, 27 ft. 6 in. in diameter, have their wooden arms and floats incased in steel, the weight of each being 66 tons. The blows of the floats break up the pieces of ice parted by the bows. When the steamer made its first trip to Detroit on January 13, 1889, the run from the yards of the builders, the Cleveland Shipbuilding Company, Cleveland, was made in eleven hours and twelve minutes. For an hour and a half the speed was reduced, and for fifty miles the steamer broke her way through ice 4 in. to 6 in. thick. Her average speed in open water was twelve miles per hour, and this was only reduced to ten miles per hour through the ice.

The hull is covered with a steel deck and has a collision bulkhead forward, in addition to bulkheads between the store room and engine room, between the engine room and boiler room, between the boiler room and the after engine room, and at the end of the stern tube. Between the bulkheads belt frames occur on every sixth frame, except for 60 ft. in wake of the paddle wheels, where they occur on every other frame.

In addition to the paddle wheels, there is a screw propeller 9 ft. 6 in. in diameter, also designed for breaking heavy ice. The screw shaft is 10 in. in diameter and 52 ft. long, and is inclined 2 ft. 4 in. in 49 ft.; the propeller projects 12 in. below the hull proper, being protected by a solid forged skag, which carries the bottom pintle of a solid forged rudder. To protect the rudder when backing in heavy ice, there is a heavy forging immediately over the rudder, and extending down to its top line. This forging is covered by the outside plating of the hull, and when backing into heavy ice the rudder is put amidships and a heavy bolt inserted through the forging into the rudder frame from the deck, thereby holding the rudder rigidly in a fore and aft direction. The after end of this forging extends down over the after corner of the rudder to prevent ice being in between the rudder and the horn.

The paddle engines (Figs. 2 to 4) do not drive direct on to the paddle shaft, but communicate their motion through spur gearing. This consists of a cast steel pinion 5 ft. 4 in. in diameter, gearing into a spur wheel 16 ft. in diameter and 5⅝ in. pitch. The spur wheel is built with a cast iron center and arms in two pieces, and with a rim in twelve cast steel segments. All the teeth are machine cut. Each paddle wheel has its own independent engines and gear. These have each two cylinders, 28 in. in diameter by 48 in. stroke. These engines have their air pumps driven independently by a beam engine (Figs. 6 and 7) with a steam cylinder 16 in. in diameter by 36 in. stroke; this drives two air pumps and four bilge pumps, while its center column forms a jet condenser common to the two paddle engines.

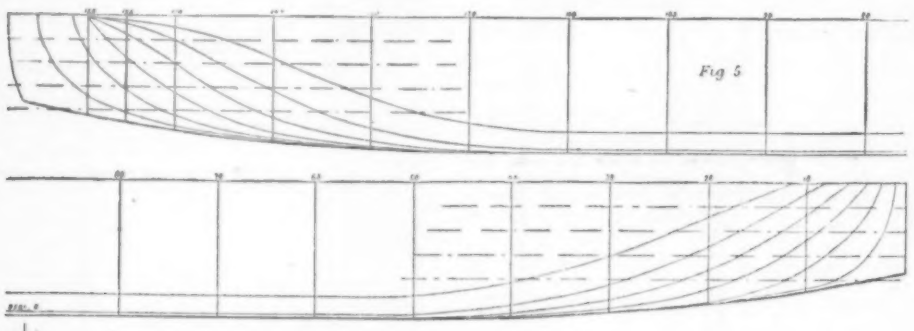


Fig. 5

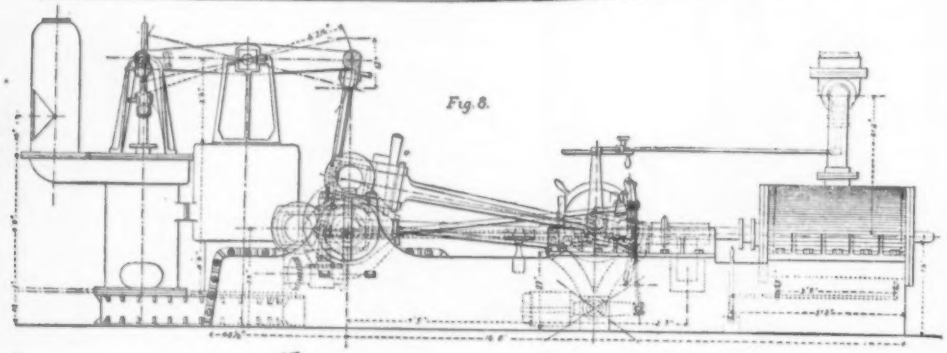


Fig. 6.

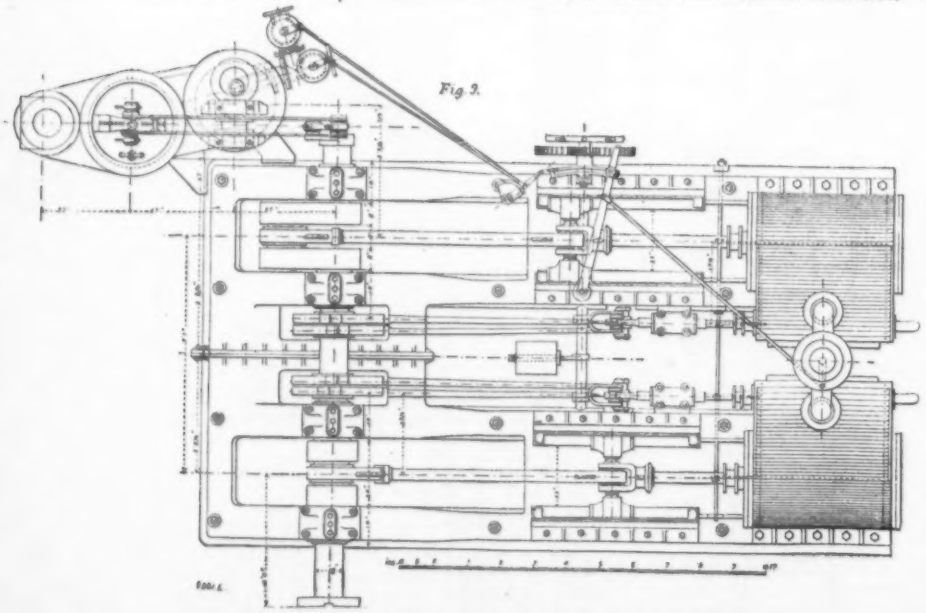


Fig. 7.

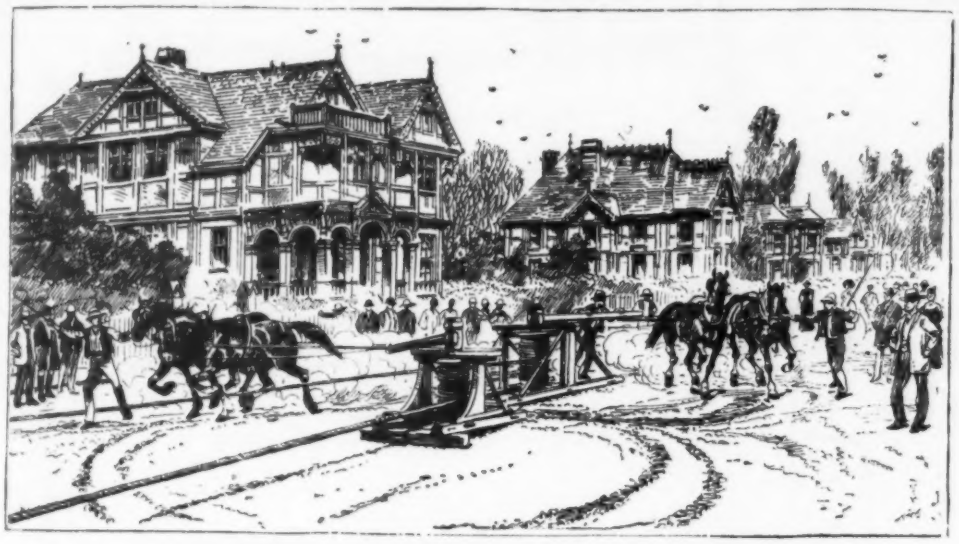
THE FERRY STEAMER TRANSFER.

The screw propeller is driven by a pair of horizontal engines (Figs. 8 and 9) having cylinders 28 in. in diameter by 36 in. stroke, with a separate air pump driven off the end of the shaft.

There are four boilers of the rectangular firebox pattern, 11 ft. 6 in. in diameter and 16 ft. long, carrying a working pressure of 90 lb. The aggregate grate surface is 350 square feet, and the heating surface 9,828 ft. Along the center line of the hull, between the boilers, are two steam drums connected to a steam separator. The funnels are at each side of the hull, and the bunkers amidships between the boilers, extending the full length of the boiler room.

Every room and compartment of the hull and paddle houses is supplied with coils of pipe for steam heating. On account of the great difficulty of getting water when working in ice, this vessel is provided with ten sea cocks, located in different parts of the ship. In engine room is a Reynolds patent heater, 42 in. in diameter, 10 ft. high, also three pairs of duplex steam pumps for fire purposes, feeding boilers, washing decks, pumping bilges, etc.

The career of this ferry boat will be watched with a great deal of interest, and if successful will certainly lead to other boats of the same type being built. It must be a very fine sight to see her plowing her way through ice six inches thick, as if unconscious of its presence, and leaving it behind her broken into fragments by the blows of her ponderous paddles.—*Engineering.*



HOUSE MOVING IN SAN FRANCISCO.

HOUSE MOVING.

WE give some illustrations showing the process of house moving in San Francisco. The house in question is an ordinary wooden villa, and it was removed to a vacant lot half a mile distant. The first process is to put cross beams under the building; these rest on two other beams—one on each side—and these again rest on short rollers at each end. Then by means of horse power applied to a winch, the house is moved in the required direction, out into the street, and along it, turning corners, and until the building is landed at the desired spot. This is an everyday occurrence in San Francisco, and it frequently happens that the occupants continue to occupy the house while it is being moved.

THE PHYSIOLOGICAL BASIS OF THE SENSE OF BEAUTY OF FORM.*

By ALBERT GOODMAN.

NO apology will be needed for this subject on account of its being unworthy of your attention, for its proper investigation requires the combined powers of various sections of the scientific and artistic world. The only reason it is not more frequently dealt with seems to be that it does not happen to fall exclusively into any one department of human study. To do full justice to it, the knowledge of the artist, the anatomist, the engineer, the mathematician, the optician, the physiologist, and the anthropologist could all be usefully employed. In introducing this subject I think myself fortunate in being favored by the obliging attention of a society such as yours, which, in such a matter as this, is to be preferred to that of any other profession. I conceive we have no professional body which occupies a similar position to that of a society of architects; for both collectively and individually an architect has to be, not only a jack of many trades, but also master of each one of them. The architect must be master not only of the principles of the various trades which carry out his conceptions, but he has to share their technical knowledge to a large extent. All this necessitates a philosophic mode of thought combined with highly mechanical and artistic powers. It is just this combination of mind which is requisite to solve such a problem as that before us.

The sense of beauty in general is a highly complex mental feeling. The sense of artistic beauty is somewhat less complex. The mental sense of artistic beauty of form alone is of a more simple nature. The term beauty used in connection with art is interchangeable with enjoyment or pleasure; for that which is artistically beautiful is enjoyable, and that which is artistically ugly is painful in the art sensations produced by it.

We have here to consider the beauty of form rather than the beauty of color, or the beauty of texture, or the beauty of alternation or graduation of light and shade. Some may have a little difficulty in abstracting the idea of form from that of color, not being in the position of a man who is born color blind, and

* A paper read at a meeting of the Society of Architects on February 25.—*The Architect.*

thus has it already done for him. Turner's pictures, I understand, especially excel by reason of their coloring. Yet a skillful engraver can entirely dispense with that element and still produce a copy of one of them which conveys many of the artistic merits of the original. Apart from connection of ideas with regard to his subject and beauty of texture in his material, the sculptor has little besides beauty of form to depend upon. This connection of ideas is apt, more than we are aware of, to obscure many of our finer artistic feelings. For instance, a realistic representation of a snake, although its form may be rendered in an artistic manner, would produce pain rather than pleasure in some sensitive minds. One can well believe that a slave looking upon the beautiful curves of the whip lash would, through connection of ideas, fail to appreciate their artistic merit.

To arrive at the correct estimate of the art beauty of any form, we should choose some object that does not in our mind connect itself with the idea of an especial use or purpose. It is difficult to entirely fulfill this condition. Perhaps a beautiful vase is as good an object as any for practical experiment in analyzing sensations as to beauty of form. A design intended solely for ornament would do still better, being in itself far more free from any connection of ideas of use. But an ornament bears relation to those surrounding forms and outlines, apart from which it would not have been designed; nor can it be considered properly or to such advantage when isolated. But, to proceed, it goes without saying that in looking at any art form the eye, and the eye alone, is concerned in transmitting to the brain, or producing in the mind, the consciousness of the particular form observed. The eye, like a machine, acts upon the art object which may be instinctively thought of as the raw material, while the sensation of beauty may be regarded as the manufactured article. To vary the metaphor, the eye is the interpreter between the object and the mind, and he who would have his message properly conveyed must so arrange it as to be within the powers of the interpreter. To do this, he must know the limit and range of those powers.

In purely optical questions the eye is generally considered apart from the muscles which guide it, and is thought of as a system of lenses which project a picture upon the retina on the inner surface of the globe of the eye opposite the pupil. That the picture is there, and that some sort of an impression is conveyed to the mind by the mere fact of its being there, is not to be denied, but that any impression approaching in delicacy to an art sensation can be produced while the eye is unmoved, is not to be believed; and such an idea is negatived by the very structure of the retina itself, which shows that the continuous and varied use of the eye muscles is a necessity for acute vision. Although like a globule in actual shape, the eye may be fitly likened to a photographic camera. The camera has compound lenses, so has the eye.

Both have a focusing apparatus; the camera has a piece of ground glass at the back, and the eye has a retina to receive the image. On the ground glass the photographer rules some lines in pencil to show the limit of accurate definition, and the intersection of two diagonal ones indicates the point where he intends that the most important part of the picture shall be brought by the adjustment of the camera, and where he will place the sensitive plate to receive it. The retina of the eye has just such another point or spot, vision being there most acute. When any object is carefully examined or examined at all, or perhaps one may say even looked at or consciously noticed, the eye is so moved as to bring in succession upon the sensitive spot each part of the image of the object that is engaging the attention. These eye movements are of course produced by the eye muscles, and are instinctively performed.

As we have said, impressions are conveyed without any muscular action to the brain by means of the optic nerve; these impressions are of course very vivid as regards color and amount of light, but in the particular matter of appreciation of art form, a retina rigidly fixed seems to have little or no power, indeed the ordinary appreciation of form is not nearly so acute as we are apt to imagine.

Until instantaneous photography came in, artists had failed, after years and generations of observation, to obtain a correct idea of the shape of a flash of lightning. For although the effect through the optic nerve was most intense and lasting, such is the inconceivable shortness of the time that even the excessive rapidity of the eye muscles could have no effect whatever in conveying exact appreciation of the form by bringing the outline of the flash successively on to the sensitive spot. Now that we are pretty well familiar with these photographs, we can easily persuade ourselves that we can now see distinctly and correctly that which we failed to see in years gone by.

We have then to consider how the muscles of the eye, like the arms of the photographer adjusting the camera, so move the globe of the eye as to cause each part of the image of the outline examined to pass over the sensitive spot. When a blind man endeavors to obtain an idea of the shape of an object, he moves his hands along its outlines by means of the muscles of his arms. If the object were moved by another person so that it touched the blind man's hand, no impression of form would be conveyed to the blind man's brain. Now the image upon the retina of the eye is like a little model of the outline of the object, and this model is within reach of the sensitive spot; and the sensitive spot, like the hand of the blind man, is moved along the image by means of the eye muscles. It is our purpose to consider the nature of the sensations of the eye muscles.

We of course, as a rule, use our two eyes in combination, but there is no reason to suppose that for artistic purposes a single eye would not be able to derive similar artistic pleasure from art forms. Indeed, the flatness of pictures not being considered a drawback to them, almost proves this. However that may be, it will be best to consider the action of one eye alone, remembering that in whatever manner the muscles of one eye are moving, the corresponding ones of the other eye are moving in just the reverse way.

Of the six muscles which move the eye, four are called the recti, and the remaining two are called the oblique. The four recti consist of two parts, and the two oblique are also a pair; thus making three pairs. Each of these couples is called a pair, because one muscle pulls the eye one way and the other muscle pulls it in nearly the reverse direction. The superior rectus pulls the eye so as to aim it upward; thus in looking at a vertical line this muscle would move the eye upward and its pair, the inferior rectus, would pull it downward, one resting while the other worked. The external rectus moves the eye along horizontal lines, and its companion, the internal rectus, pulls it also horizontally in the reverse direction. For the purpose we have in view, the superior rectus and inferior rectus may for convenience sake be called the vertical muscles, and the external and internal recti may be called the horizontal muscles. For working upon all oblique lines one horizontal muscle and one vertical muscle act in combination, and the same is true as respects all curved lines.

Having made these broad statements, which lead up to the solution of salient problems connected with vision, certain corrections must be added, which may enable us to solve some of the more recondite points connected with art sensations. It is not strictly true of all these muscles that each one acts in exact opposition to its companion. But, as with most muscles in other parts of the body, the vertical muscles slightly miss of this. Greater steadiness of movement in a joint results from the additional action of a third muscle, however weak it may be, provided that it pulls in a slightly different direction; just as a flagstaff is more steadily raised or lowered by three cords than by two. The eye, although not a joint, moves in a socket, and is no exception to the rule we have mentioned. The oblique muscle seems primarily and almost entirely designed for steadying the eye during all the movements to which it is liable. As this goes on without intermission, and as this seems to be their especial function, we will not take account of them for our present purpose, except as regards one class of lines, namely, vertical ones; these cannot be followed by a vertical muscle alone, but it calls in the assistance of one of the oblique muscles, which fact must be borne in mind when examining the art properties of perpendicular or nearly perpendicular lines.

The knowledge of the peculiar action of these eye muscles when used in observing straight and curved lines placed in certain positions with regard to the horizon, will help us to account for some of the otherwise inexplicable phenomena of visual and artistic sense: why, for instance, the moon looks smaller when in the sky than when near the horizon; why a man, say 200 feet distant, on a tower appears far smaller than the same man standing at the same distance on the level road; why an oval is more pleasurable to look at than a circle; why a square held vertically appears higher than it is wide; why a square placed with its side obliquely to the horizon produces a different mental impression than that produced by the same figure placed in the first position; why certain arrangements of lines are visually delusive; why certain races of men have consistently for many ages preferred certain curves and arrangements of lines which find little favor with other races; why the individuals of every race have certain differences of taste from their relations and neighbors, although subject to exactly similar mental training.

Beyond saying that it is the will of the Creator that these things should be so, which is hardly an intelligent solution to these difficulties, little has been done to solve these points, except upon the lines that visual impressions as to form have some intimate relationship to the movements of the muscles which guide the eye. Simple explanations offend a certain class of mind, which seems actually to prefer a mystery to such a solution of it; yet many of us who cannot charge ourselves with this weakness are very much startled when we observe how complex a result is brought about by simple causes. For instance, the whole banking systems of the world, without which commerce and manufacture would languish, are dependent upon the fact of the muscles of each man's hand being somewhat different from those of any other person. From this it results that an individual's handwriting and signature can be recognized and distinguished from that of any one else, in spite of similar educational influences from the school master. Yet how entirely unable would the anatomist have been to predict this result, however closely he examined the construction of the hands. Let us then be careful before we reject a similar theory respecting the muscles of the human eye, upon the ground that the proof of it should have been within the reach of the anatomist.

We must look for proofs in directions other than the physical examination of the muscles themselves. Of the fact that certain motions are pleasurable to the muscles, while other motions differing slightly are not pleasurable, we have many instances. How much lovers of cricket enjoy watching a batsman whose "style" is good! It is not that he is of necessity more effective in making a score; but he is evidently using his muscles, *i. e.*, moving his limbs, in a manner enjoyable to himself as contrasted with the man of no "style." The same is true with the figure skater. Both the skater and the observer enjoy it. The skater himself, not because the figure on the ice is elegant, but because he has learned to do it in a manner enjoyable to his own muscles. Certain arrangements of muscles render certain motions enjoyable, while another arrangement renders those motions distasteful. When we wave our farewells to our friends, our hands move in ovals, not in circles. The grindstone and the treadmill for the man and the mill for the horse are proverbially unenjoyable. In short, all pleasurable muscular movements have a certain character, and all tedious movements possess another character. Change and variety, exercise and rest, are necessary for each individual muscle, if it is to be a source of pleasure to its owner. Even human eyes do not seem primarily constructed to produce artistic pleasure, but art adapts itself to the construction of the eye. The bridle is made to fit the horse's head, and it is not, as the sportsman said, "that Providence has shaped the horse's head to fit the bridle."

But while art adapts itself to the eye, the eye trains itself to appreciate art. The trained eye of the artist can readily detect if any art object will give lasting pleasure to the ordinary man, or whether it will only give temporary pleasure. At a glance he can estimate that which the public takes a decade to experience. But the public is, for a time, pleased with anything which has a certain mixture of novelty from and resemblance to that which, just at that epoch, happens to be familiar to their eyes. Artists—and in that term I of course include all architects—artists have to appreciate all this, and in their wisdom act accordingly. But architects, especially, should never forget that behind and above all this there is a right and wrong in art forms, that the public is really trusting to them to keep this standard in mind, and not to depart from it more than is needful. The stronger our belief that there is such a standard of right and wrong in art, the more we shall search for it, and the nearer we shall attain to it.

Why should art be on a less assured footing than is music? And if the very natural question be put, "Of what practical use is a physiological theory as to the art sensations of form?" it may be said, in reply, that this subject holds the same relationship to art as the science of air vibrations and the construction of the human ear does to music. The identification of certain rapidities of vibration with certain musical notes, and the responsive action of certain parts of the ear to those vibrations, may not directly help a great composer in the remotest degree. Yet music, being placed upon the assured foundation of scientific consistency, reaps an advantage from it in many other ways.

We are living in an age of fierce public investigation. Neither commerce, literature, politics, nor religion has escaped; and it is only at the expense of being despised that any science or profession can escape this scrutiny. Ruskin, who cannot be accused of being a slave to popular opinion, has from his own point of view felt the need of bringing art nearer to the fraternity of the more exact sciences; and that which masterly use of language can effect, he has effected. Vague generalities have, I trust, been for ever banished by his magic wand; but in place of them he has supplied thought far more exact and fruitful, and ideas which serve as great encouragements to the young artist, who delights to find that his own artistic instincts are in agreement with his great predecessors, and are consistent with immutable laws common to all ages. If, therefore, we can to any extent explain the mode in which sensations are produced in the brain when the eye falls upon an object of art, we shall go far to place art itself upon a more assured footing in the public estimation. Beyond this, we shall have a better means of properly estimating, at all events intellectually, the artistic merits of the art productions of other races of mankind; a matter of no small importance to architects at the present time, now that we are being brought into increasing contact with foreign nations, and the English public is becoming familiarized with Eastern art.

The practical application of these theories will, I trust, be less tedious than the consideration of the theory itself. It is interesting to take certain art forms and draw their outlines in colors or any diagrammatic way, which will show the especial muscles used as each part of the object is brought upon the sensitive spot of the retina of the eye. Let two colors, say red and yellow, represent the use of one of those two which we have termed the vertical muscles, namely, red for the superior rectus, and yellow for the interior rectus. Let brown and green represent the use of the horizontal muscles, namely, brown for the external (say the right) rectus, and green for the internal rectus. Blue and black may be used for the superior and inferior oblique muscles.

One eye alone, say the right, is taken into account; and that eye is supposed to be going round in a certain direction, say with the clock. First, take a square placed with its sides horizontally and vertically. This figure thus placed alternately employs a single muscle and then two in conjunction. The whole of the bottom line is green, showing that the internal rectus is alone employed upon that line. The left vertical line is red, showing that the superior rectus does nearly all the work, the top line is brown and the downward line yellow.

Thus each of the four great muscles works apart from the other four, and every muscle rests three times as long as it works. The horizontal muscles work alone, but this they are the better able to do, being relatively strong. The vertical muscles are weak, but receiving a little help from the oblique, they are thus slightly but not much more worked when looking at the square than are the horizontal muscles. That they are a little overworked is brought about by the fact that a square thus placed looks to be higher than it is wide. This may not be readily detected, but careful trial will prove it.

Man's easy range of vision, even with one eye, is more extensive horizontally than vertically. Hence the outline of the majority of pictures, especially large ones, is greater in that direction, not that the four straight lines which inclose a picture are for the purpose of inducing the eye to travel over them continuously, but they inclose an area over all parts of which the eye may pleasurably range. In the light of these ideas we can well understand that a vertical line will be more apt to be objectionable when unduly prolonged than will a horizontal one. Hence a dado will be an improvement in a high room, but may be inappropriate to a low one, and a wall paper with vertical lines will be more suitable to a low than to a high room.

Now place the same square with its sides at 45° with the vertical, and notice the great difference in its effect upon the mind. We hardly recognize it as the same figure. We now think of it as more resembling the diamond shape.

Beginning at the bottom, the first line is an equal admixture of red and green, the next of red and brown, then brown and yellow, then yellow and green.

In this case every muscle when working does half the work; and each muscle works half the time and rests half. The whole effect may be said to be fairly good, artistically, certainly better than when the square is otherwise placed.

Without the muscular explanation as to why the same figure produces a different mental impression when varied in its position relative to the vertical, we should have been at a complete loss, as we have nothing analogous to this in purely mental operations.

The color representation of the muscular action when used upon the circular image projected by the sense of the eye upon the retina shows that each muscle gradually commences to act, and stops equally gradually; and that no two muscles stop or start together; hence there is no particular point at which the eye can stop and reverse its action, or where it can easily glance off for the purpose of working upon to other parts of the object of the building, picture, or design, as the case may be. Hence there is no figure which tires the eye so much as does the circle.

The circle is, however, an extremely useful figure when used as an ornament, for it, as it were, entraps the eye, and is thus able to divert it from other lines which are inartistic.

When used for this purpose—and it is only for this that the unbroken circle should be used—it should subtend a small angle, as in this case it is not nearly so wearisome to the eye as when the circle appears large; for it is not so much what the muscles have to do which fatigues them as the number of degrees through which they have to move the globe of the eye.

Thus a circle should either be small, or only a portion of the whole 360° should be used. Hence the so-called Norman arch, whether stilted or otherwise, although consisting of as much as 180° of the circle, has an entirely different effect according to whether the arch is large or small relatively to the whole design. The oval, whichever way placed, presents, of course, somewhat the same features as the circle; with the exception that the relative proportion of rest and work of each muscle is different. It is therefore more pleasing as an ornament but less forcible when so used, because the eye can leave it with more facility. It is, therefore, best used in close combination with other lines.

But let us return to the circle, or rather the parts of the circle, for that curve is, *par excellence*, the one with which civilized architecture has to deal.

The poor we have always with us, and also the compass and straight edge. The civilized arts must ever chiefly avail themselves of such curves as the compass can produce. And in this necessity lies the great distinction, so far as art is concerned, between the architect and the artist or sculptor.

Civilization consists in the united efforts of individuals; and an exact appreciation of each other's ideas and acquirements is the basis of this united action.

However grand and beautiful may be the conceptions of the architect, only such of them can be utilized as can be conveyed to another mind—an inferior one it is to be remembered—by means only of straight lines, angles, and curves, which can be measured and reproduced by simple instruments.

The compass is, therefore, the architect's necessity, and his endeavor should be to render it a useful slave rather than a tyrannical master.

I suppose I shall not be far wrong in saying that the particular curves and ornaments given to arches at the present time give the chief character to each particular style of architecture.

Those who first used the semicircular arch were of a vigorous race, but were more marked by their energy than by the delicacy of their feeling.

They found pleasure in the half circle used in combination with a bold, or even coarse, capital at the base of the curve. The unwearied muscles of their eyes needed but little rest or change; and when such a rest is taken, it is merely a change to an equally energetic recreation. As the color diagram indicates, the horizontal muscles are employed through the 180° of the curves, commencing and ending gradually. The vertical muscles work over 90°, commencing suddenly and ending gradually, or *vice versa*.

The Gothic arch, being suited to a more highly trained eye and to a mind which could more delicately appreciate its own sensations, only works the vertical muscles over some 60° instead of 90° of the whole circle, and the horizontal muscles over some 120° instead of 180°.

In addition to these advantages, the horizontal muscles commence just as gradually, and all through have less strain thrown upon them, while the capitals at the bases of the curves, whose purpose is again to refresh the muscles, may be of a less coarse form. Hence the Gothic arch, with its accompanying delicacy and varied carving, and the subtle tracery of its windows, is the glory of Western art, however ill adapted that style of architecture may be to the necessities of life.

The stilted arch, which seems to have been common to the Europeans and Moors, although so small a departure from the Norman, has yet a markedly more delicate effect upon the eye. This, perhaps, results from the more complete rest which the horizontal muscles receive after their exertion, as is shown by the color diagram.

The Moors neutralized the artistic evils of the half circle in another ingenious manner, however constructionally defective their arches may be. In their horseshoe arch they somewhat prolonged the curve by continuing the arch inward beyond the 180°.

The curious visual effect of this is easily explained by the color diagram, for it will be seen that, commencing where the Norman arch would end, a fresh horizontal muscle is worked for a short time, and then an entire rest is given to both muscles by a horizontal line making an acute angle with the curved line.

The Moors also modified their horseshoe arch by making a change similar to that from the Norman to the Gothic, giving the apex a pointed rather than a round form, accompanied with the consistent changes at the bases of the curve; but all of you will be much more familiar with these matters than I am myself.

Had there been no racial difference in art forms, the muscular theory would have been very one-sided and incomplete, however strong it might be against any other theory; but wherever a homogeneous race of men is found, there is also a distinct style of art. The gradual mixture of races, in some countries, confuses and obscures these differences of style.

Conquered races generally receive an admixture of the blood of their conquerors, and hence cease to be homogeneous in their race and also in their art forms, for the influence of the conquering race will be detected for an indefinite period after such an admixture.

The pure Tartar race, in the general conformation of their bodies, perhaps exhibit more vigor, and are to our eyes more uncouth than any other nation, and their style of art exactly corresponds to this description.

Again, the Arab races present physically, perhaps, the finest examples of grace combined with activity which the world can afford, and here again their art forms correspond thereto.

What these two races have done by successive attacks upon the other nations is within easy historic reach. The effect of these two great waves of influence, each starting from the home of the race, may still be seen.

The more ancient art forms of Egypt and Greece had already become, as it were, petrified long before this, and they stand up as rocks in the midst of this sea of Tartar and Arabic art influence. But European art of the last thousand years seems to be the resultant of the meeting of these two waves upon the Celtic and Scandinavian races, and the resultant of these various forces is exemplified in the Gothic style of architecture.

It may be of less interest to us as Europeans, but from a cosmopolitan point of view it should also be noted, that the Malay archipelago is the center of a third great racial form of art.

Japan seems to be the meeting point of this Malay type and the Tartar type as modified by the Chinese. And India seems the meeting point of all these three waves or influences.

I will not further pursue this branch of the subject, nor will time allow me to adduce as arguments the interesting correspondence between the art forms and the cursive handwritings of various nations, especially as I have already alluded to the individuality of handwriting.

The next diagram I will trouble you with is the outline of a vase. A closed and irregular figure such as this, by the breaks in the line of any one color, indicating the use of one muscle, better illustrates the successive and the proportionate work and rest of the muscles in a good art form than will the more geometric forms we have been considering.

Any artistic picture, whether inclosed in four lines or otherwise, may in like manner be considered as a complex and interlocked system of outlines, skillfully so arranged by the artist that the eye of the observer is pleasurably exercised thereby, as, with inconceivable variety and rapidity, it travels in all directions, leaving no part of the picture unvisited.

Of course, in a picture although not colored, graduations and alternations of light and shade take the place of that which we have termed outlines. But the addition of these new elements, and also the more complex one of color, while they add to the intricacy of the subject, also add to its interest and importance. In alluding to its principles of ornamentation we must remind ourselves that although for our present purpose we speak of outlines only, and also speak of those outlines as though they were hard lines, yet a graduated shade or the line of contact of two colors is for our purpose virtally an outline—its attractive force to the eye being according to the difference between the two colorings or the abruptness of the change of shade.

Some people who are not minutely observant of their own sensations are somewhat skeptical as to whether the eye does or can move with the immense rapidity and in the intricate manner alluded to.

They can, however, prove this to themselves by noticing the extreme speed with which the eye can run down whole columns of mixed names or words, detecting the one sought for directly the eye meets it, for it is self-evident that each previous word has been examined.

Again, by intently observing the engine turning on a watch case, the dizzy feeling it produces, owing to the eye continually moving along circles alone and those of exactly the same radius, would confirm the idea.

Again, some people, who do not give sufficient importance to the muscular theory of visual impression, or who disbelieve it, have found themselves puzzled to account for the fact that whereas the image on the retina of the eye is upside down, we see it, as they express it, right way up. Of course there is really no "up or down," "left or right," to a mental impression. Nor is there to a visual impression, except as respects the movements of the muscles. Let us suppose we are looking at a church spire; then the image on our retina is with the spire pointing downward. Let us say the point of the spire is below the sensitive spot. When the muscles of the eye aim the globe upward to the point of the spire, the image of the point comes upward on to the sensitive spot.

Thus the upward movement of the eye becomes connected in the mind with the top of the object looked at, the downward movement with the bottom, the leftward movement with the left side, and the rightward movement with the right side of the object, and all our muscular sensations accord with the real position of the object looked at.

According to the same theory which we are considering, the principles or ornamentation are not far to seek. The general effect of any structure may be, or may not be, pleasing to the eye. If it be pleasing, it will require no ornament. If it be unpleasing, ornament becomes a necessity. But this is putting the matter in far too bold a manner when applied to an important work of art, such as a large building. And for this reason: The whole of such a building can never be seen at any one time, and every part will be looked at from a variety of distances. The influence of distance upon any line, as to the effect on the eye, is of great importance.

Relative size of lines in art is self-evidently of supreme importance, as the whole thing depends upon that, but actual size, although all other parts are increased or decreased in the same proportion, is also of much consequence.

As we have pointed out, it is an entirely different thing to the eye whether it looks at a large circle or a small one, or, which comes to the same thing, whether the circle it looks at is near to or far off.

A building, then, looked at from a certain distance, may require no decoration, but when viewed nearer may be ugly unless that ugliness be corrected by decorative additions, or by slight or harmless modifications of the structure.

When the eye is so close to a wall that no part of the structure of the wall is seen, the texture of the external substance of the wall acts as a decoration by giving the eye fit employment. On stepping farther back, the texture is lost sight of, and at this point some structural lines, such as the joints of the stones, come into view. But if the texture is lost sight of before some such structural lines employ the eye, the wall must be decorated, and the size of the pattern of this decoration must be such as to employ the retreating eye until the observer can catch sight of some structure or ornament. Thus the wall paper of a large room must have a larger pattern (supposing panels or dadoes, etc., are not used) than one employed for a small room.

But let us imagine the observer to be so far away that some portion of the structure does catch his eye; at this point all texture and small decoration lose significance, and ornament may be needed—but only in case of the lines of the structure then in sight not happening to be such as would please the eye.

In that case an ornament becomes needful, but this must not be too coarse, too heavy, too marked, or too strong (whichever adjective is most appropriate to the nature of the ornament). We say, the ornament must not be such as will arrest the eye when the eye is at such a distance as to allow of a more comprehensive view of the whole structure.

To sum the matter up in a sentence. When the form of any structure, say a building, is not pleasing to the eye, that is an evil which should be remedied as far as possible by ornament; but if the remedy does not cease to have visual effect at the distance at which the evil is lost sight of, then such ornament becomes an evil, and the remedy may prove worse than the disease.

I have endeavored to place the whole subject before you in its broad and comprehensive form. Hence I have not attempted extreme exactness in anatomically describing the combined action of all the six eye muscles. But I believe you will find that the differences between anatomists as to these matters leave our theory unaffected. And had we still further simplified the matter by only taking into consideration one of the horizontal muscles, together with one of the vertical or even the superior oblique and the external rectus, and examined the effects upon those alone, I believe most of the points we have noticed would have been brought out nearly if not quite as well.

I cannot, of course, for lack of time, now deal with the more fascinating part of my subject, which consists in the application of the muscular theory to details of ornament such as to the exact sizes of circles, to the proportions of ellipses, spirals, quick and slow curves combined, contrasted curves, zigzags, angles acute and obtuse, chequerwork, the inclinations of roofs and spires, etc.

In conclusion, I must make my apologies to such an assembly as the present for having touched upon so many points in which you are experts. But such errors as I have fallen into will not, I think, be found to affect the general scope and bearing of the subject.

EMILE MULLER AS A CERAMITIST.

EMILE MULLER was not only an eminent engineer and a brilliant professor, but he was especially and above all a ceramitist, and applied all the qualities of precision and scientific method, which characterized him to so high a degree, to the practice of a calling in which success is very difficult. In fact, there are few industries that require an amount of knowledge so varied, and in which true science is so indispensable. This is something that is not well known or not generally admitted. How many persons are there who fancy that it suffices to put into the fire any sort of argillaceous earth in order to take it out a perfect brick or a faience of fine quality! How many manufacturers are there who are regarded as illustrious on account of a few fortunate successes, who are unable to reason as to their success!

The question of art left aside, a good ceramitist should, before all else, be a scientist.

As an accomplished chemist, he should study the composition of the earths that he has in hand, he should know how, for a definite purpose, to associate with the argillaceous material (the basis of his industry) the substances that will give it the requisite qualities, he should know how to modify the relations of these elements according to the nature of the final product that he is endeavoring to obtain, he should compel himself to analyze his mixtures in order to assure of the constancy and regularity of his wares, and should so calculate and prepare the composition of coverings and glazes as to make them harmonize strictly with the clay mass that they cover, or else run the risk of seeing them crack or swell through the effect of unequal expansions.

As an experienced physicist, he ought to search for in his crude material, or communicate to it, those qualities of plasticity and homogeneousness that are indispensable in moulding, and that are necessary for giving the desired strength to the manufactured products, he should study the question of the temperature adapted to each material, he should regulate the action of the gases that exert so varied effects upon colors, and he should be able to construct apparatus in which the heat is well utilized and properly distributed in order to obtain during the successive bakings of the same nature a perfect and uniform constancy, as each clay mass and each glaze acquires its absolute and relative qualities only at a definite temperature.

Such are, in a general way, the attainments indispensable to an enlightened ceramitist, to the man who relies not upon chance (to which we too willingly ascribe a preponderant role in the art of firing), but upon science, whose rules are immutable. Muller possessed these in all their detail. Profound study had developed the qualities that were born with him, and rendered him capable of giving success and prosperity to his industry.

The Ivry Port Works, near Paris, were founded by Muller in 1854. At this epoch their exclusive object was the manufacture of bricks and tiles, but they did not long follow this limited field of operations. Muller was one of the most ardent promoters of the application of ceramics to architecture and of its association with metallic constructions. The Universal Exposition of 1878, and that of 1889 especially, showed with what boldness he had entered this path, and the unusual dimensions of the pieces that he has been able to produce testify both as to the security of the processes and the extent of his means of action. It is almost useless, *apropos* of the late exposition, to recall the large part that Muller took in the external decoration of its marvelous palaces: The eight Allard medallions with children, which are 5¾ ft. in diameter, the four great Darwant friezes with lyres and rams' heads, the four pyramids that decorate the entrance porch of the Palace of Liberal Arts, with Michel's statues (*Pax et Labor*), the forty-eight vases, 11 ft. in height, that surround the great blue domes, etc., are still present to the minds of all. They excited the astonishment of connoisseurs and the admiration of everybody.

To the manufacture of terra cottas, Muller began in 1866 to join that of glazed products. In collaboration with the lamented Parvillée, he produced large pieces of all colors for the exposition of 1878, and, since then, he has given this part of his industry a wide development. The exposition of 1889 showed us all the advantage

that we can henceforth derive from architectural ceramics. Mr. Loebnitz, the modern master of stanniferous faience, pointed out the way. Muller, with slightly different means, proved to architects that their exigencies may be hereafter almost without limits.

He has shown this with his great panels, in which the artistically managed color of the earth so skillfully brings out the brilliancy of the glazes; with his medallions, rose windows, and balustrades, which are as interesting by the variety as well as the fineness of the tones; and, finally, with his mosaic tiles of the domes of the Palaces of Fine and Liberal Arts. Each of these domes comprises 620 types and models of different tiles, a number necessitated by the combinations of forms and colors demanded by the architect; and the resources of the Ivry Works may be appreciated when it is stated that the order for these 200,000 tiles was not given until the month of June, 1888. Now, in order to be on time, it was necessary that no accident should occur, that there should be no failure in the baking, and that no piece should come defective from the furnaces, which were new ones constructed for the occasion. The programme was carried out, and Muller's science rewarded his boldness.

Up to 1874, the English were the exclusive masters of the French market for one of the most important ceramics, that is, stoneware. Muller, moved by patriotism, endeavored to introduce this industry into our own country, and devoted several years to a study of the mixtures of clays necessary for undertaking this manufacture, which now comprises the ordinary stoneware for pipes, sewers, hygienic apparatus, chemical apparatus, and stoneware of various colors for building and architectural ornament. But, after he had discovered the composition necessary for rendering his products identical with those of the English, as regards appearance, etc., he found that competition would be almost impossible with the English at the price at which they delivered their wares at Paris. It was only after great sacrifices and incessant efforts to devise economic apparatus that it became possible to found this industry at Ivry, where there is now produced everything that enters into the construction of sewers and of hygienic apparatus.

The manufacture of decorated, colored, and glazed or unglazed stoneware has been greatly extended at Ivry during the last year, and we observed most perfect specimens of the ware at the exposition, especially in the basement of the Palace of the Argentine Republic. The beauty of the material, its strength, and the brilliancy of the glazes employed in the decoration predict a certain future for it, both for the exterior and interior of dwellings.

Specialists will recall with pleasure the panel exhibited in class 20. The mode of decoration was of great simplicity, and left upon the eye the agreeable impression of a sketch in which the talent and the hand of the artist preserved all their originality.

Such, in their broad features, are the services that Muller has rendered to the ceramic art; but, not to forget anything, we must mention another important branch of this industry to which he likewise devoted his intelligent activity, and that is refractory products. Along with the usual products, which he manufactured like all his confreres, and which we shall not dwell upon, it is well to mention in particular those of which the invention belongs to him alone—bricks of silica and magnesia and plumbago crucibles. The first of these manufactures dates back to 1869. Before this epoch all our industry was tributary to England. Muller showed that silica, under well defined conditions, was capable of becoming a plastic material, with which it was possible to mould bricks for metallurgic and glass furnaces. The perfection that he was enabled to give his products by the selection of his crude material and by the care with which he shaped them gave him a success that was so much the more meritorious in that he had to compete with a country in which fuel is much cheaper than it is in France.

The discovery of bricks and other products of magnesia dates back to the same epoch. After three years of research, the manufacture of these was established. Muller proposed them to French metallurgists for the construction of furnaces, and pointed out to them the advantages that they would derive therefrom through the elimination of phosphorus and sulphur. Unfortunately, his tentatives were not crowned with success, for, at the moment, the advantages that he proclaimed were not recognized, although experience has since confirmed them most brilliantly. Despite this first relative want of success, the honor is due to Muller, and it is but just to proclaim the fact.

As for the manufacture of plumbago crucibles, Muller attempted this for the first time in 1868. He resumed it after the war with complete success, as regards quality if not pecuniary advantages, for it was not until after ten years of persevering research and great sacrifice that he was enabled to liberate our arsenals from the tribute that they were paying to England.—*Abstract from Le Genie Civil.*

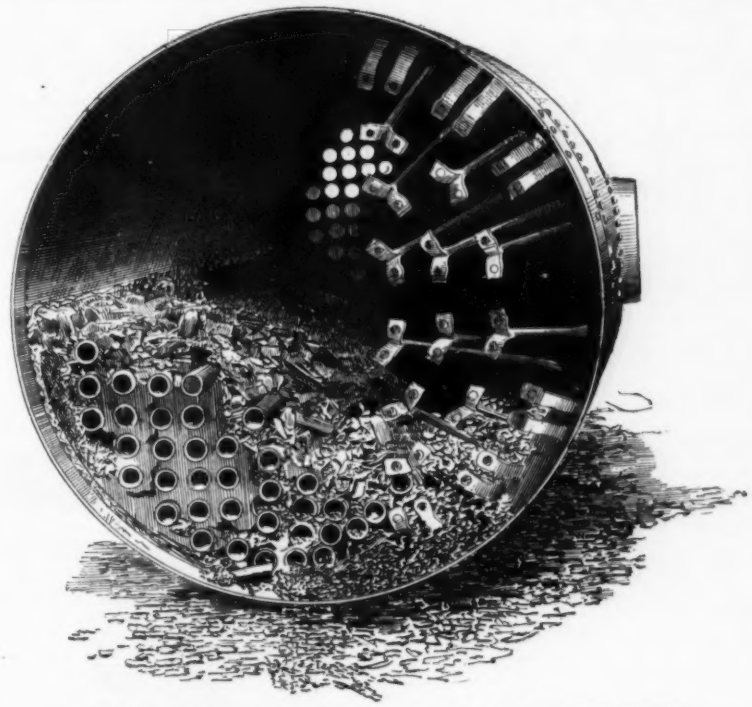
DANGERS OF BOILER SCALE.

THE accompanying illustration from a photograph represents a bad case of incrustation. The boiler was of the locomotive type, seventy-two inches in diameter, twenty-two feet long, with 153 three-inch tubes; shell, three-eighths; head, three-eighths, and made of iron.

The feed water was Croton water pumped from an open heater. The exhaust steam from the engine was used for the purpose of heating this water, and the impurities in the water were taken up with oil from the engine added and went into the boiler through the feed pump. The boiler was in use for several years, and was tested by hydrostatic pressure by the Police Inspection Bureau every year, and a certificate given that it was safe and in good condition. The American Steam Boiler Insurance Co., of New York, inspected it and condemned it; but the owners still continued to use it for several months, when the company's inspectors appeared and threatened to throw up the insurance. Thereupon the boiler was broken up, as shown in the illustration.

The scale against the back head is nearly two inches thick and completely fills the space between the tubes, so that circulation must have been impossible, the only wonder being that the boiler did not give out before. It was only the solid mass of sediment that held it together. The scale was even with the top row of tubes; the only part of the boiler generating steam was the fire box and the upper row of tubes, the others acting simply as smoke conduits. This was certainly a great loss of fuel, quite fifty per cent., and how the engineer could generate steam enough in this boiler to do his work was a mystery. Had it been of the horizontal tubular style, it would have burned out before the scale had become so heavy, and possibly caused great loss of life and damage to property.

This shows the necessity of a thorough inspection internally rather than sole dependence upon hydrostatic pressure. This boiler was very inconvenient and troublesome to thoroughly inspect and clean, as manhole and hand-holes were wanting, and the only way to learn of its condition was by a thorough internal inspection.—*Safety Valve.*



A REMARKABLE CASE OF SCALE GROWTH.

MACHINE FOR DRYING AND IRONING LINEN.

THE pavilion of the gas industry at the exposition contained in the basement a certain number of bleachery apparatus heated with gas. The use of the latter with a view of obtaining the heat necessary to finish linen is of considerable interest to the laundry industry. The substitution of gas for steam, which has been used up to the present with apparatus of this kind, leads, in fact, to a simplification in the construction and avoids the dangers of explosion, while gas is better adapted, at the same time, for use with machines of small size.

Among the machines exhibited may be mentioned, as being in the first rank, Messrs. Piet & Co.'s new drier and ironer. We present herewith two engravings, one of them giving a general view of the machine, and the other a transverse section of its principal parts.

Upon examining Fig. 1, it will be seen that this machine consists essentially of a roller, C, provided with a suitable covering, and of a hollow and concave iron, A, heated internally by a row of gas lights supplied

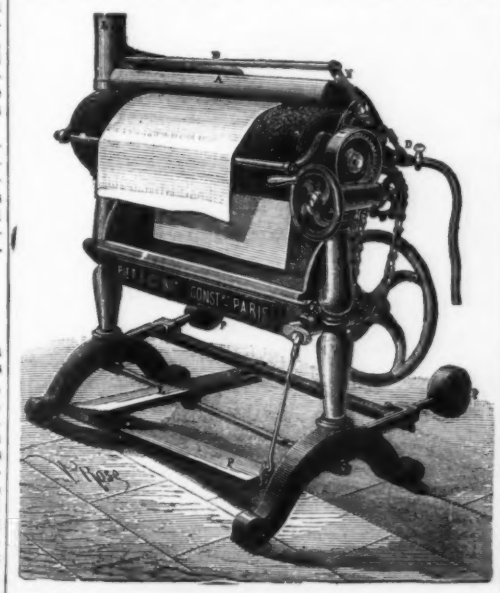


FIG. 1.—DRYING AND IRONING MACHINE.

through the cock, D. The levers, N, connected by the rod, B, permit of making the iron tilt backward and around its lower joint. At B the products of combustion are directed into the pipe, E, whence, owing to the draught produced, also escapes all the vapor derived from the ironing of the damp linen.

The journals of the drum, C, are guided vertically by the two uprights of the frame. Under the action of the pedal, L, they are capable of taking on a certain eccentricity with respect to the iron, A, so as to form between the upper generatrices of these two pieces a suitable interval for the introduction of the linen to be ironed. The counterpoises, P, tend constantly to keep the cylinder against its iron. The levers of these are jointed with the legs of the frame, a little in front of the uprights, which latter are traversed by a rod that connects the levers with the bearings of the drum, C.

As for the rotary motion, that is obtained by means of the pedal, P, which actuates an intermediate shaft, F, provided with a hand wheel and a gearing chain. This latter actuates the axis of an endless screw, which in its motion carries along a pinion keyed to one of the journals of the drum, with which this latter mechanism moves vertically. The hand wheel serves besides to start the pedal.

Referring to Fig. 2, we shall give a few details as to the essential arrangements of this machine.

The hollow iron, *b*, shown in section, is of cast iron and is polished upon its concave side. Above the row of gas jets that heat it there are sheet iron plates for forcing the flames, *c*, to lick the effective side of the iron and to direct the products of combustion into the elbow, *d*, and then into the pipe, T.

The drum is surrounded with flannel or calico. The two positions that its axis occupies will be noticed. One of these, shown by dotted lines, corresponds to the period of operation; the other is the one that permits of the introduction (in the direction shown by the arrow, V) of the piece, H, to be ironed. In returning to its first position, the drum exerts upon the concave side of the iron a pressure which, as we have before stated, is regulated by counterpoises. The iron likewise is represented in its positions of work and rest. In order to permit it to resist the thrust of the cylinder, it is made to engage through a hook, K, with a piece cast in the frame. This mechanism is controlled by means of the reversing lever, P, which is jointed at *o*, and terminates in a tail that plays between the stops, *m* and *n*.

It is thus possible to raise the iron and to fix it with ease in the proper position, and then with the pedal, L, to regulate the pressure of the roller upon the iron, according to the pieces to be ironed.

An iron plate guard, *a*, completes the jacket of the half-periphery behind the drum. The role of this is to cause a strong draught of air through the flow of the hot gas into the pipe, T. This ventilation finishes the drying of the fabric, and, at H, carries along the vapor formed during the ironing.

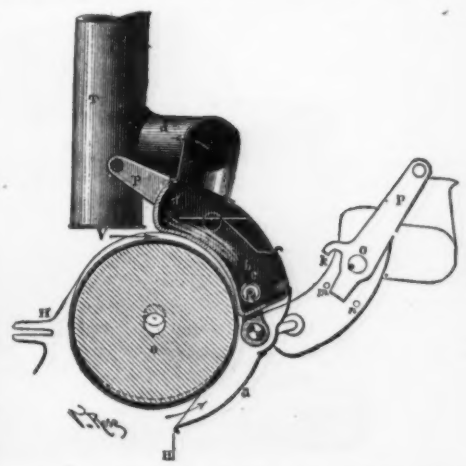


FIG. 2.—SECTION OF THE IRONING DEVICE.

These new combinations of the parts of the machine permit of drying linen and of ironing it at once upon its coming from the wringer.—*Revue Industrielle.*

BBEWING AT THE EXPOSITION OF 1889.

SINCE the Exposition of French Brewing at Paris in 1887, we have noticed that French brewers have made great progress in their industry, and that our principal manufacturers of brewing apparatus have introduced great improvements into them. We propose to pass rapidly in review the most recent apparatus that are used, and that figured at the exposition of 1889.

Mr. Henry Carpentier is one of those who has most contributed to the improvement of the apparatus un-

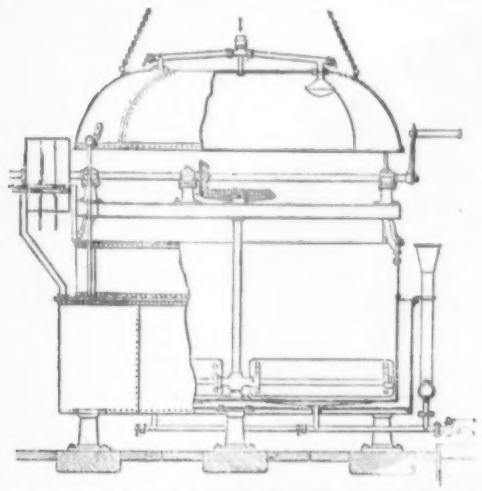


FIG. 1.—HALF ELEVATION AND SECTION OF A MASH TUN.

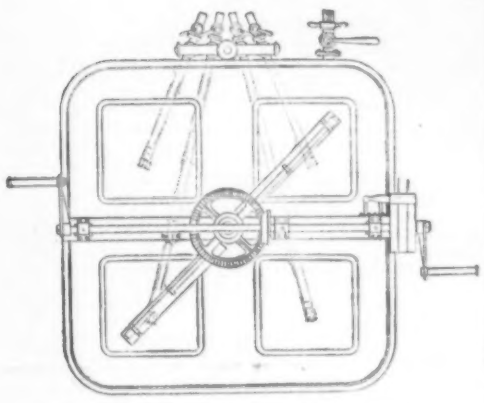


FIG. 2.—PLAN OF THE MASH TUN.

der consideration. He exhibited, among other apparatus, a grain cleaner, a square, double jacketed mash tun, an underback, and a tun for the oxygenation and cooling of the wort, protected against the germs of the air.

The grain cleaner is an apparatus designed for cleaning the kiln-dried malt and freeing it from germs before it passes to the mash tun. It consists of a crusher, and a brush for removing impurities from the grain.

The square mash tun is wholly of metal, with a double jacket for the circulation of steam around the four sides and under the entire surface of the bottom, so as to keep the infusion at the desired temperature during the stirring as well as during rest, and even permitting of raising the temperature. This jacket may be braced so as to operate with steam under pressure. In this case, it is provided with the necessary safety apparatus. In most cases, the jacket receives merely the steam that escapes from the engine, or a small amount of live steam, which is more than sufficient to keep up the desired temperature.

The tun rests upon five cast iron legs that hold it at such a height as to permit of easy access to the piping in order to clean it. Sockets on the external jacket receive brackets that support a bench at the desired height. A trap traversing the double jacket permits of the easy removal of the spent malt.

The cover of the tun is convex and of iron plate, and is guided by four vertical rods with rings for the lifting chains. A sprinkler is fixed to the cover. It is formed of four copper roses, with pipes that lead hot water coming from a central coupling that communicates through a flexible rubber tube with the steeping boiler. As this entire system is fixed to the cover, it is removed with the latter and is always ready to operate through the simple opening of a cock.

In this tun there are four separate compartments with concave bottom, four finely perforated false bottoms with a wide surface, four copper pipes that put the false bottoms in communication with the distributor and the cocks, and four bronze cocks.

The oxygenating and cooling apparatus replaces th cooling back. It is so arranged as to receive the boiling wort under protection from the air.

This apparatus (Fig. 3), which is wholly of metal, has the form of a half cylinder. It is closed by a cover with a hydraulic joint and lifted by four chains. In the interior there is a shaft that carries a number of disks containing wide apertures, and that has a rotary motion. The apparatus has a double jacket with movable joint.

After the boiling wort has been introduced into the apparatus, the cover is lowered into its groove, and the disks are set in operation. Air which has been previously sterilized and made very cold is introduced through one extremity of the cover, and a current of incongealable liquid is let into the double jacket. In this way the wort is simultaneously oxygenated by the current of air and cooled by the refrigerant liquid. This double and rapid action takes place under shelter from the germ-laden air.

The disks are finally stopped, and the wort, cooled to the desired degree, remains immovable; the dregs sink to the bottom. The wort is then drawn off through tubulures placed at suitable heights.

The Pictet ice machine is now employed in a goodly number of breweries for the cooling of the fermenting tuns, etc. This we have previously described.

We have also described the FIXARY ice machine, and we shall therefore limit ourselves here to a description of the various apparatus forming a complete installation (Fig. 4), that is to say, the compressor, A, the condenser, B, and the evaporator, D.

The compression pump, A, sucks up liquefied anhydrous ammoniacal gas into the evaporator, D, and forces it into the condenser, B, where, before entering the worms, it traverses an apparatus called the oil separator. The particles of oil carried along with the gas separate and fall to the bottom of the receptacle, C, which is divided into two compartments, while the gas, purified and freed from oil, passes through the worms of the condenser, wherein it liquefies under the pressure of the pump and the action of the cold water in circulation.

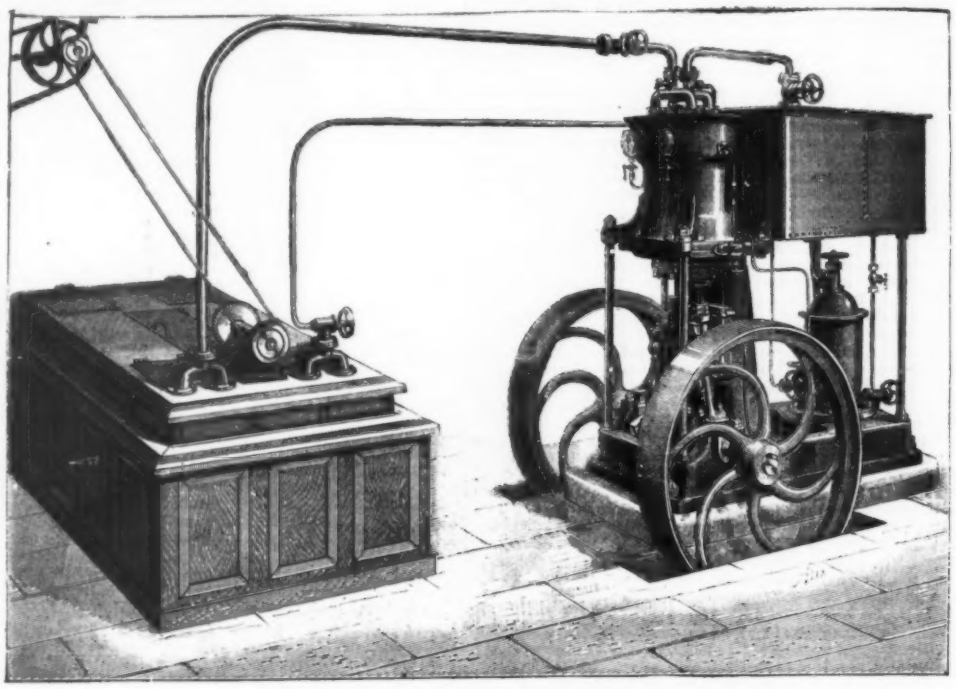


FIG. 4.—A COMPLETE COOLING PLANT.

The liquefied ammonia is collected in the upper compartment of the receiver, C, and is led from there to the expansion and regulating cock, R, whence it passes in a gaseous state into the worms of the congealer, D, and produces an intense coldness. From the congealer, the expanded gas passes through the suction pipe, H, to the suction pump, A, to be again compressed, liquefied, and expanded in a continuous circulation.

The heavy oil, separated from the gas and led to the lower compartment of the receiver, C, is carried back automatically, by a small pipe under the piston, to the bottom of the compresser, where it forms a hydraulic joint, lubricates all the parts of the pump, and prevents leakages through the stuffing box.

The compression pump (Fig. 5) consists of two vertical chambers, A. Each chamber is provided at the top with a suction valve, B, and a force valve, C, which serve to suck the gas into the congealer and force it into the condenser.

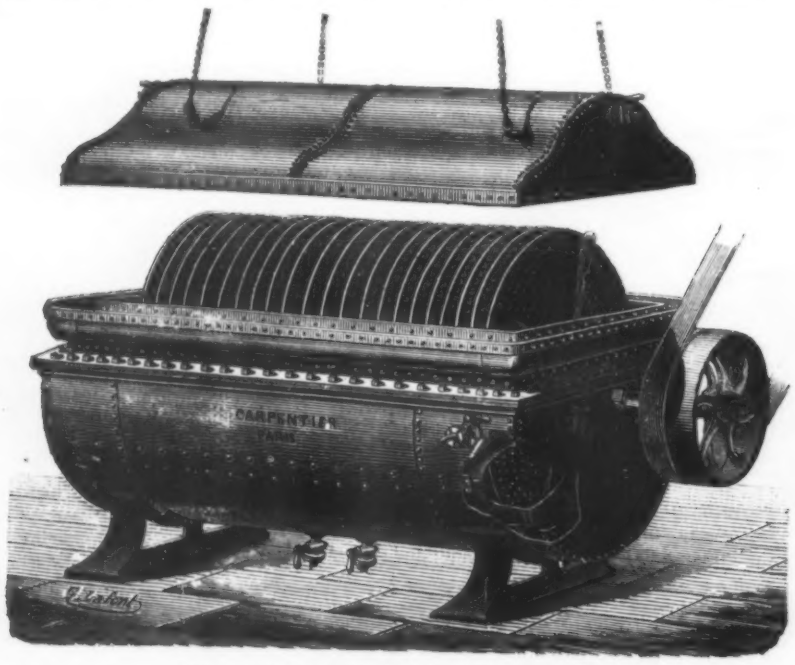


FIG 3.—OXIDIZING AND COOLING BACK.

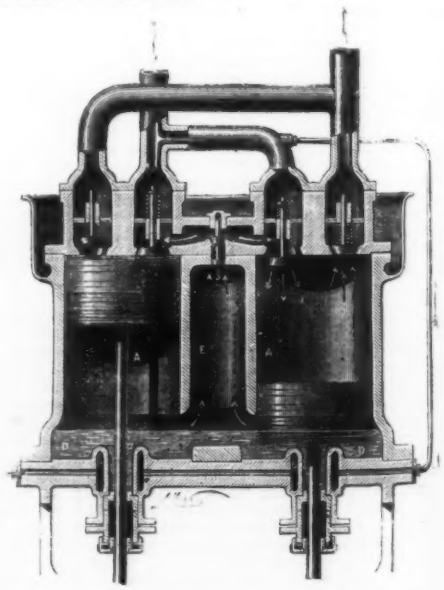


FIG. 5.—SECTION OF COMPRESSION PUMP.

The gas therefore only enters over the pistons, which are simple acting. The vertical arrangement permits of keeping a stratum of oil constantly above the pistons, so that when the latter alternately reach the limit of their stroke the oil fills all the dead spaces, lubricates the valves, and forces the entire gas to the condenser. Beneath each piston there is a free space, D, called the oil chamber, which is constantly filled up

to a given height with heavy mineral oil, into which the head of each piston plunges at the end of its downward stroke. Grooves in the circumference of the piston become filled with oil at every stroke and lubricate the pump chambers in the upward stroke.

There are at present several filtering apparatus used in breweries. Of these, we may mention Stockheim's and Enzinger's as giving the best results.

The Enzinger filter (Fig. 6) is mounted upon a rolling

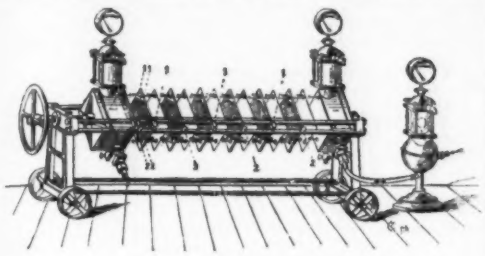


FIG. 6.—ENZINGER FILTER.

frame to the right and left of which there are two reservoirs movable upon iron rods surmounted by boxes provided with pressure gauges. Between these reservoirs, and likewise movable upon rods, are placed square plates of tin, variable in number and size. These have apertures above and below, and have grooves on their surfaces for allowing the beer to pass. Between these tin plates are interposed square sheets of filtering paper of the same size and also provided with apertures. The reservoir to the left is made to slide up to the plates, and the whole is made tight with a screw. After the apparatus has been mounted, the beer coming from the tun, under the pressure of the air, enters the filter through the reservoir to the right, drives the air before it, traverses the filtering paper, and makes its exit, filtered, through the reservoir to the left.

The Stockheim filter (Fig. 7) consists of a flattish copper drum movable upon two axes fixed upon a

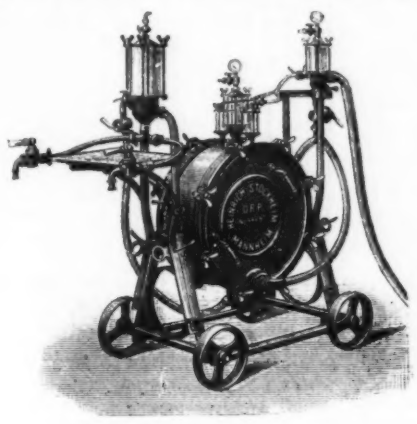


FIG. 7.—STOCKHEIM FILTER.

frame. When it is desired to charge the apparatus with filtering material, the cover is removed and the material, previously moistened with water sterilized by boiling, is arranged in two distinct layers between perforated disks of tinned copper and of wire gauze. When the drum is full, the cover is put on and screwed down tightly, so as to exert a pressure upon the filtering mass. The apparatus is then placed in a vertical position, and this allows the water that served to equalize the filtering material to escape through a cock.

In this filter, the filtering material is a mixture of cellulose, fibers of conifers, and textile fibers. It is entirely neutral and chemically pure. The washing of it, which is done with boiling water, steam, and cold water, guarantees its perfect innocuousness and renders it free from all taste. Beer that has traversed this mass is of a perfect limpidity, and has lost none of its carbonic acid, and has improved in its taste.

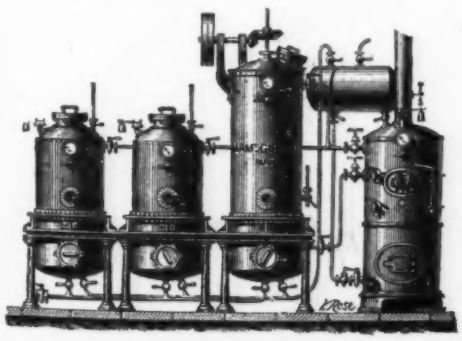


FIG. 8.—IMPROVED STEAM BREWERY.

When the apparatus is set in operation, the air in the conduit leading to the filter is first expelled, and as soon as this has been done, the space that leads to the two side chambers of the filter is opened. The beer that enters leads in air, and froth forms up to the small boxes at the highest point of the chamber. As soon as the chambers are full of beer, the cocks of the boxes are closed, and the beer, being under pressure, is forced, after the opening of an air cock, to traverse the filtering mass. What water may have remained in the latter makes its exit from the central chamber through the cock beneath, it being forced out by the beer. As soon as all the water has made its exit, the cock is closed. The beer then rises in the central chamber, and drives out the air through the box. As soon as the latter is full, its cock is closed, and the beer, being under pressure, flows into a pipe leading to an isolating chamber, which prevents froth from forming.

In consequence of the more elevated position of the isolating chamber with respect to the central one, there forms a column of pressure, which, acting as a counter pressure, prevents froth from forming in the apparatus. When the gauge marks a pressure of from 5-10 to 7-10 of an atmosphere, the work of drawing off the beer may begin.

It now remains for us to speak of Armand Girard's system of steam brewing. This comprises the following parts:

1. A steam generator of a power corresponding to the quantity of beer to be made per brewing, and provided with all the accessories necessary for its operation.
2. A saccharifier or mash tun with its agitator or oar, and capable of being closed hermetically, so as to work under pressure.
3. Two boilers for heating water and boiling hops.
4. A galvanized filtering back, with perforated bottom and a small galvanized reservoir.
5. An iron frame upon cast iron legs, supporting the boilers.

The transfer of the contents of one boiler to the other, and of the wort or beer to the filtering back or the cooling backs, is effected through cocks adapted to each apparatus. Pumps are entirely suppressed.—*Le Genie Civil.*

APPARATUS FOR REGISTERING VELOCITY.

THE use of instruments of measurement and verification is the origin of nearly all the progress in the sciences as well as in the industries, and with a view to perfecting the different systems of locomotion, exact means of measuring velocities are sought for. We observe that mariners are attaching great importance to the selection of the best log, that engineers are devising tachygraphs, that is to say, apparatus for continuously inscribing the speed of trains, and that manufacturers are demanding apparatus that permit of recording the velocity of their engines. There is nothing, up to the modest cab, for which a counter is not sought for, that is to say, an instrument that gives the traveler the satisfaction of knowing the distance that he has made and the time that it has taken him to make it.

Physiologists on their side have need of accurate instruments when they study the different forms of motion in the functions of life; the velocity of the blood in the blood vessels, that of the air in the bronchial tubes, and that of the various animals that move upon the earth, in the water, or in the air. For this they have special means.

Although they aim at nearly the same object, the various experimenters employ very different means. This is doubtless due in part to the diversity of the conditions under which they operate. It is very probable, however, that the instrumentation would be simplified and would tend to become uniform if attention were paid to the principles that should preside over the inscription of every motion. Now these principles have been admirably laid down by the French engineer Ibry.

The employes of railways would be much embarrassed to follow the complicated motions of the trains that run over their lines had they nothing to give them information but the instrument with which the public is content, and which is called an indicator. But with the Ibry diagrams it is possible to see at a glance the number of trains that are running upon a road, the direction in which each is running, its speed and stoppages, the points at which two trains cross, and the place where each should be at a given moment.

This graphic expression of motion, the simplest and most perfect that has ever been conceived, is obtained with extreme facility; a line drawn obliquely upon ruled paper shows, by its direction and various inflexions, the direction of each train's motion and all the phases of its speed. In the construction of a machine which interprets the running of a vehicle, it is necessary before all to aim at obtaining an inscription of this nature, unless we are content with a very imperfect idea of the motion.

The counters applied to the wheels of vehicles or to screw propellers show, it is true, at the moment at which they are consulted, the distance made from the beginning of the motion, but they do not show the speed made during the trip. Such instruments are very valuable for effecting summary measurements of land, or rather for comparing the relative lengths of two itineraries that lead from one point to another, but here their utility comes to an end. In fact, if, in order to complete the readings of the counter, the instant of starting and that of arrival were carefully noted, even that would only permit of estimating the *mean speed* of the trip, that is to say, a speed that perhaps has not existed at any instant of the journey, since accelerations, retardations, and even stoppages may have occured.

A counter does not show all these accidents of a journey. If we wish to keep a trace of them, we necessarily require special instruments that faithfully inscribe the *speed at every instant*, with all the variations that it exhibits.

The studies that we have been pursuing for a long time upon the locomotion of men and animals have led us to construct instruments of this kind.

The reader has already seen in these very pages a description of the speed-registering apparatus which we have named the cylinder odograph. The instrument draws a diagram of a motion by means of a style which moves parallel with the generatrix of a cylinder covered with ruled paper. The cylinder revolves with a uniform motion, and the style moves with a speed proportional to that of the vehicle. From the combination of these two motions, which are at right angles with each other, results the curve of the spaces traversed as a function of the time, that is to say, the complete expression of the motion.

In practice there is one difficulty that arises when the inscription of a motion must be made continuously over a very long stretch, and for a very long time, and that is that in order to inscribe a curve of this kind, it would require a very great surface of paper. In fact, let Fig. 1 be a diagram which expresses the fact that a pedestrian is uniformly traversing one hektometer per minute. The curve of the motion will be the diagonal of a square whose vertical sides correspond to the division of the distance in hektometers, and the horizontal sides to the division of the time in minutes.

It will be seen from this figure that in order to express the motion during the first minute, it requires a piece of paper only 5 mm. square, but that in order to inscribe it during 2 minutes it requires a square four times larger, and, for 3 minutes, a square nine times

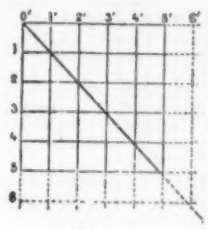


Fig. 1.

larger, and so on, the surface of the paper that receives the inscription being proportional to the square of the time during which the motion is inscribed. It follows from this that the inscription which would express a walk of half an hour would almost entirely cover a page of *La Nature*, that for a walk of 3 hours and 20 minutes the surface of paper necessary would be a square meter, and, finally, that for a trip of 12 hours, and even more, that is so often made on railways, the surface that received the inscription would be several meters square.

Such necessities would render the method wholly inapplicable to the inscribing of long journeys, but fortunately there are several means of escaping them. One of these consists in reducing the scale of the diagram. This is effected in the cylinder odograph by reducing both the velocity of the revolving cylinder and that of the style. But this means must be applied with discretion, otherwise the small inflections that express the different variations of the speed would be so reduced that they would become inappreciable. Another means consists in sacrificing the continuity of the curve, and of obtaining it in successive sections, each corresponding to the distance made during a certain time chosen as unity. This means has great advantages. On the one hand, it much reduces the surface of the paper necessary for receiving the inscription, for such surface is no longer but simply proportional to the distance traversed; on another hand, in the construction of the inscribing apparatus, instead of a heavy, bulky, and cumbersome cylinder, a small bobbin covered with an endless band of paper is used. This, as we shall see, constitutes a very great simplification.

Fig. 2 shows an example of these broken inscriptions. The paper band that receives the latter moves at the rate of half a centimeter for each hektometer of space traversed. In this way the scale of the spaces keeps its continuity. As for the scale of the time, that is

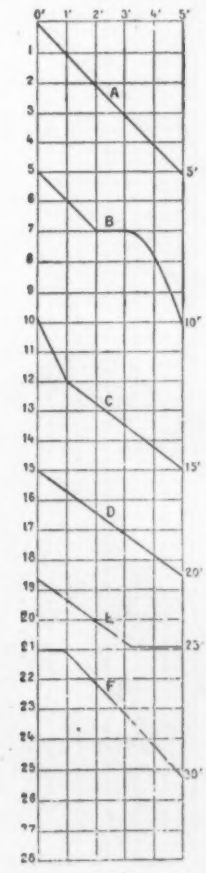


Fig. 2.

broken up into small intervals of five minutes each, during which the style moves uniformly from left to right, that is to say, from the division 0' to the division 5'.

For a duration of five minutes, matters progress absolutely as in Fig. 1. In fact, the oblique line drawn at A shows that the progression was uniform, and that the speed was one hektometer per minute. At the end of this first interval of time, let us suppose that the style moves suddenly to the left of the band of paper; then it will begin again to draw a new curve, which will be the section B, in which the speed is at first the

same as in the section A. Then we observe a stoppage of one minute measured by the length of the horizontal part that the style has traced. After this stoppage, the gradual inflection of the curve shows that the motion has accelerated and has reached, toward the end of the inscription, a speed of 200 meters per minute.

The section C indicates, in the first place, the continuation of this speed; then, at the eleventh minute, the motion is suddenly retarded; through section D and a part of E, it preserves its velocity. The pedestrian then halts, after walking 21 hektometers. The stoppage lasts three minutes and occupies the end of section E and the beginning of F. This latter is finished with a uniform speed. At the moment at which the inscribing ends, 2,530 meters have been traversed in 30 minutes. It would be superfluous to multiply examples in order to make it understood how the different variations of the speed of a pedestrian are expressed graphically.

The apparatus that gives this kind of inscriptions is represented in Fig. 3. A wheel provided with two

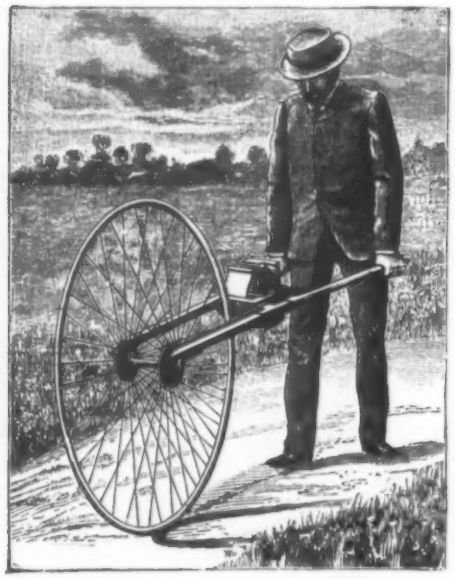


FIG. 3.—THE ODOGRAPH APPLIED TO THE MEASUREMENT OF A MAN'S GAIT.

handles is pushed before him by the pedestrian, just as he would push a wheelbarrow. Each revolution of the wheel corresponds to a constant distance. Now the wheel, through a connecting rod, controls a click that acts upon the mechanism of the registering apparatus. Each to and fro motion of the rod causes the tooth of a ratchet wheel to pass, and this transmits its motion to a small roller between the cylinders, from which an endless band of paper unwinds. In this way the paper moves forward a distance proportional to the distance traversed by the wheel upon the ground. In the arrangement adopted for studying the gait of man, the speed of the paper was regulated in such a way that a millimeter of paper corresponded to a distance of a hundred meters upon the ground. At the same time that it is thrust forward by the roller, the paper band is traversed by a style actuated with uniformity by clockwork. This style (Figs. 4 and 5) takes one hour to traverse the band, whose width is six centimeters. Now, as it would be pretty difficult to estimate, by the eye simply, the fractions of the hour, a

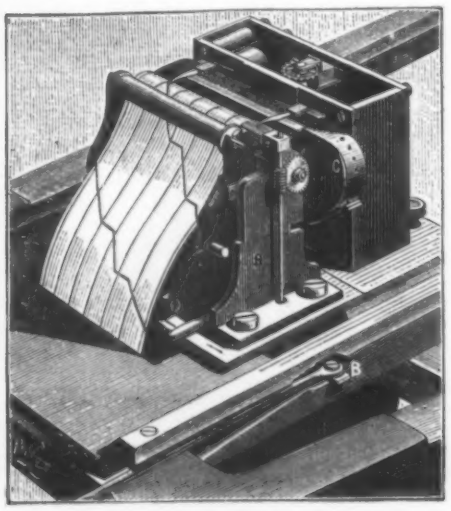


FIG. 4.—DETAILS OF THE ODOGRAPH.

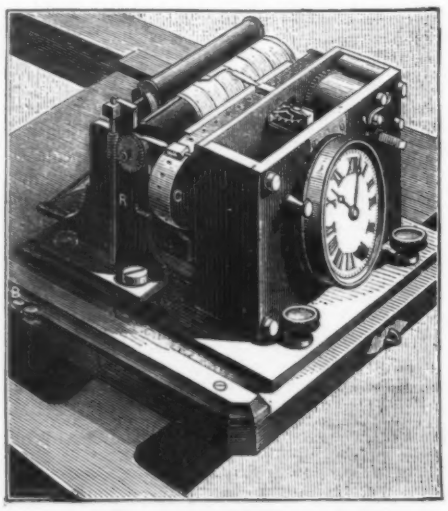


FIG. 5.—OBLIQUE VIEW OF THE APPARATUS.

sort of comb with thirteen equidistant teeth draws upon the paper, in measure as it advances, lines whose intervals correspond exactly to the twelfth part of an hour, that is to say, to five minutes.

The principal difficulty was to arrange things so that at the end of every hour the style that had traversed the band and escaped at the right edge of the latter should pass without loss of time to the left edge and begin a new inscription. We reached that result by means of a series of five styles fixed at six centimeters from one another upon an endless steel ribbon. This latter, moved around two rollers by clockwork, revolves continuously at a velocity of six centimeters per hour. When one style has traversed the band, the following one is all ready to inscribe in its turn.

The paper that receives the inscription is covered with a coat of zinc white. The styles, which are of German silver, and have sharp angles, make an inscription upon such paper without sensible wear. Without speaking of accessory details, such as setting the clock and regulating the style, and the method of substituting a new band of paper for the old one, etc., we shall try to show the many applications of the odograph with endless band.

The instrument just described was originally constructed for studying the gait of soldiers; but it is applicable likewise to all sorts of vehicles for registering their running. Thus, I propose to adapt it to velocipedes and tricycles, in order to ascertain the influence exerted upon their speed by the inclination and nature of the ground, and the mud or dust that covers it, etc.

Let us state that, according to the habitual speed of the motion that it is desired to study, it is necessary to regulate the revolution of the roller in such a way that the mean velocity of the paper and that of the style shall be as nearly equal as possible. Under such circumstances, if the vehicle preserves its normal speed, the slope of the curve traced will be 45°, as in the example given in Fig. 1. According to the inclinations of this curve, we can very easily follow the variations in the speed, either above or below its mean value.

This regulation of the motion of the paper is obtained once for all according to the pitch of the endless screw that controls the roller. But if an odograph regulated for the running of a carriage were applied to high speeds (to the running of an express train, for example), the band of paper would be carried along too rapidly by the roller, and not only would there be too much paper used, but the inclination of the curve drawn would be less favorable for the estimation of the speed.

Through the kindness of Mr. A. Eichthal, we have been permitted to apply the odograph upon the Southern Railway, where experiments are being made under the direction of Mr. Millet, engineer in chief of traction. Fig. 6 represents a fragment of an inscription obtained upon an express train running at a mean speed of 55 kilometers per hour. The odograph was regulated for the much slower running of a carriage, so the paper unwound much too rapidly and increased the scale of distances out of proportion with that of

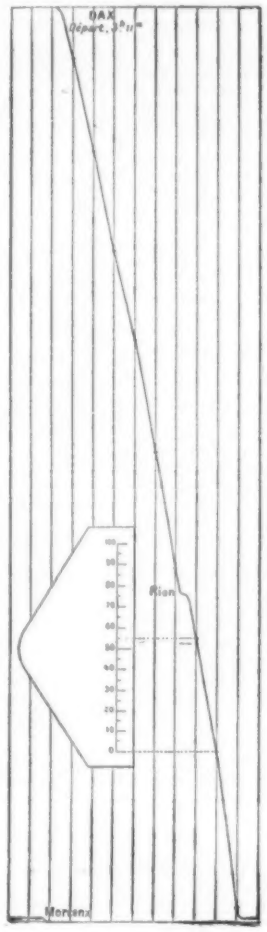


FIG. 6.

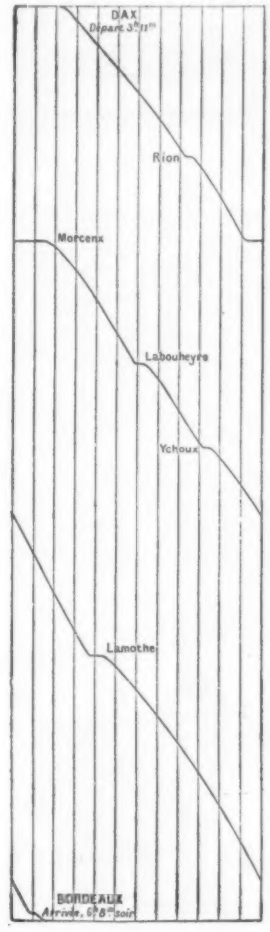


FIG. 7.

the time. The section of this trip represented in Fig. 6 expresses only the distance made in 49 minutes from Dax to Morcenx.

It is true that we find in this figure everything that we can have an interest in knowing—the phases of the increase in speed on starting from stations and the quick stoppage produced by the action of the brakes. As for the absolute speed, this is accurately ascertained by means of a scale which, according to the length of a trip corresponding to a run of five minutes, permits of directly reading the speed in kilometers per hour. But in this figure, the predominance of the scale of the space traversed over that of the time is very unfavorable for the estimation of the variations in speed. They can be followed much better in Fig. 7, where the scale of the distances is reduced about four times. This reduction permits of taking in at a glance the entire running of a train between Dax and Bordeaux.

There is no occasion for explaining here the peculiar arrangements that would render the apparatus more specially applicable to the registering of the running of trains, those, for example, which would change the direction of the paper according to the direction of the running during the maneuvers. The different means of transmission—mechanical, electric, or pneumatic—by means of which the revolution of the wheels of a vehicle move the paper of the odograph, we shall not occupy ourselves with. It has been simply a question here of showing that the same method and the same apparatus may serve to register, upon land, speeds of progression that vary within wide limits. This same method and same apparatus would be easily applicable also to the measurement of the speed of a ship, every revolution of a helix log acting like that of the wheel of a vehicle in causing the paper band to move. We should thus have, not only as with the log with a revolution counter, the total of the distance made at a given moment, but also all the variations that have occurred in the speed of the vessel. Now a knowledge of changes in speed is very important in certain cases—for example, for regulating the evolutions of a squadron.

Thus the endless band odograph permits of measuring speed both upon land and water. We have even applied it successfully in measuring the velocity of the wind. Generally speaking, our instrument, applied to any counter whatever, will show through a curve the varying discharge of water, gas, etc. Adapted to a hydraulic wheel, it will give the variations in the velocity of the current of a river; and connected with one of the turnstiles that count the visitors to an exhibition, it will give the curve of the frequency of the entries, thus showing at what hours the visits of the public are the least or greatest in number. With quite simple arrangements, it is possible to actuate the apparatus through the motions of the heart or those of the respiration, so as to obtain a curve of their frequency and their variations under different influences.

This very brief enumeration of the applications already made and of the possible applications of the

endless band odograph shows, as we said at the beginning of this article, that the same instrument can be applied to the measurement of all sorts of velocities. It seems as if this rendering the means of measurement uniform ought to realize a progress.—*E. J. Marey, in La Nature.*

TWENTY-FIVE TON ICE-MAKING PLANT.

THE engravings represent an ice-making machine and plant on the ammonia compression system, designed and manufactured at the Nine Elms Iron works, London, S. W., and erected at Birmingham by the Pulsometer Engineering Company.

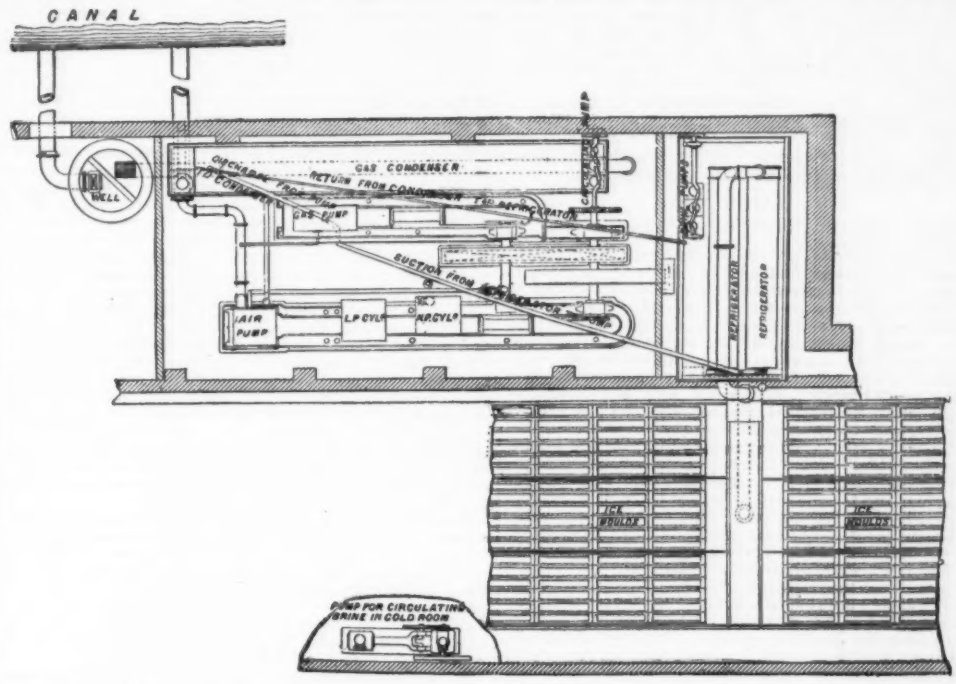
The apparatus has been satisfactorily at work since June last, producing one ton of ice per hour day and night, and at the same time maintaining, at a temperature below the freezing point four large chambers for the storage of meat and provisions. The apparatus is constructed under Puplett's patents, and is the second machine made under these patents for the same proprietors. Many other similar machines have been erected within the last four years in England and abroad, all of which, we are informed, are working successfully.

Freezing machines in which ammonia is used as the frigorific medium are now admitted to be the best of their kind for all purposes, and they may be counted by hundreds in America and on the Continent. Hitherto, however, where the supply of condensing water is scanty or of high temperature, the excessive pressures at which it has been necessary to work have been a fruitful source of trouble, and especially has this been the case in instances where the temperature of the water has risen to 75 deg. or 80 deg. Machines made with the improvements incorporated in the machine illustrated—which are secured by letters patent—are able to work with water at a temperature of 100 deg. Fah.; for example, the condensing water available at Birmingham during the past summer was frequently as high as 90 deg., and notwithstanding this high temperature, the liquefying pressure was only 175 lb. per square inch, and at no time was the output of ice diminished in consequence.

The apparatus comprises a horizontal tandem type compound condensing steam engine, having cylinders 11 in. and 21 in. diameter respectively, with a stroke of 30 in. The air pump is a single-acting plunger pump, 10 in. diameter, the plunger being of gun metal, working through a gun metal bushed gland. The valves are twenty in number, of India rubber with brass guards, arranged on valve plates which are secured in their places by wrought iron cross bars with set pins. The high pressure cylinder is fitted with the ordinary slide valve, and a cut-off valve with Meyer's gear. The low pressure cylinder has the ordinary D slide valve only. The governor is of the Porter type, operating a specially designed equilibrium valve. The wearing surfaces are large, the main bearings being 6½ in. diameter by 12 in. long, and the brasses are in three parts, and are provided with both vertical and horizontal adjustment. The crosshead is proportioned for a weight of 24 lb. per square inch of surface.

The gas compresser is horizontal double acting, having two inlet and two outlet valves which work vertically, so that no springs are required. The valve covers are provided with an adjustable screw stop, by which the height of lift can be regulated without removing the covers; a spindle passes through these stops which is screwed to engage in a hole tapped in the valve, and by this means the valves may be lifted or ground in without removing the covers. The stuffing box around the piston rod is provided with an inner and outer packing, and between the two packings an annular chamber is formed around the rod; this chamber is connected by two pipes with an oil reservoir fixed above the pump, and which is charged with oil; any gas escaping past the inner packing passes up one of the pipes into a reservoir. A circulation of the oil is thus set up.

The top of the reservoir is connected with the suction

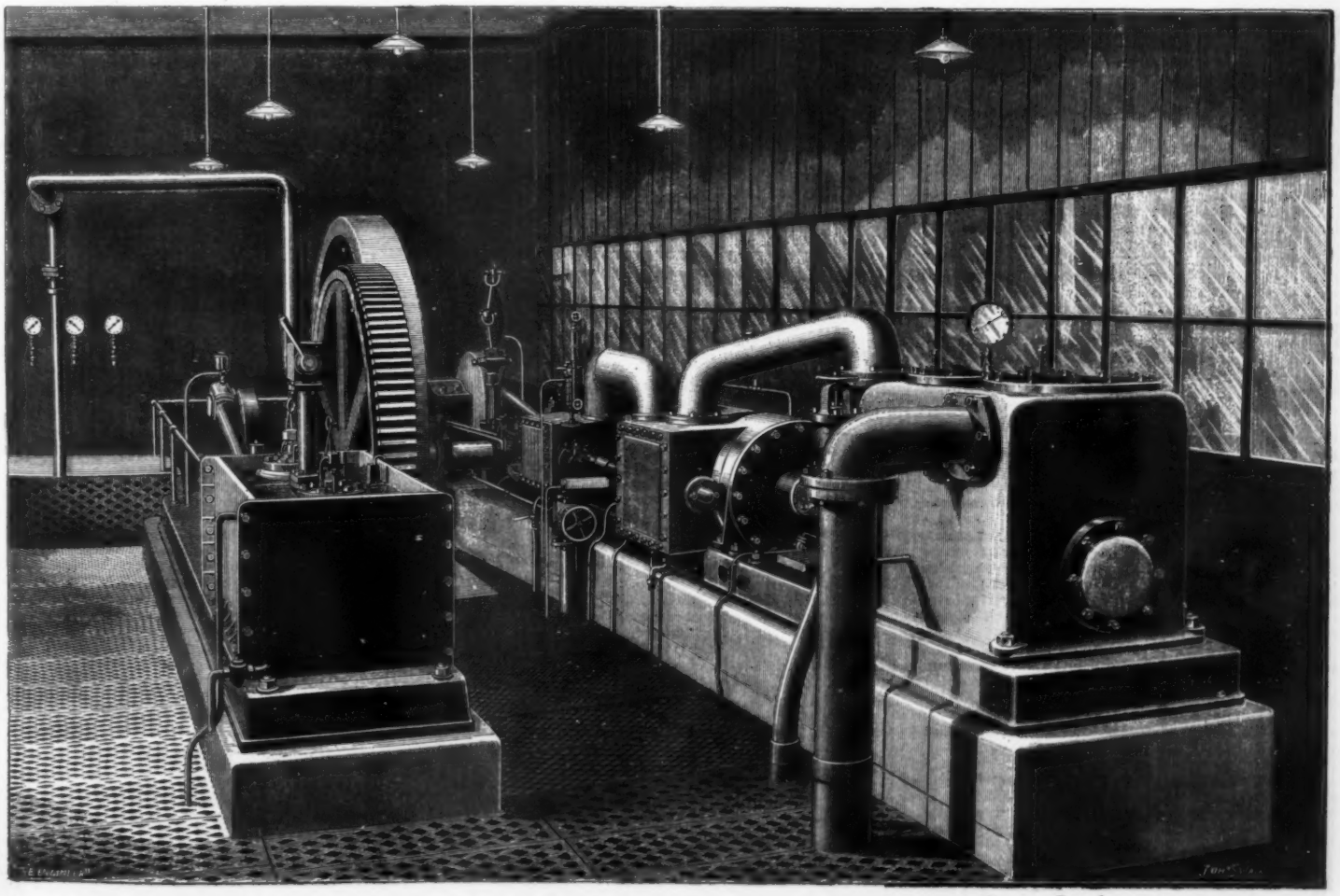


pipe of the compressor, consequently all the gas is removed from the reservoir at each stroke of the pump, and loss of ammonia is absolutely prevented, and although the compressor has been running night and day since June, the gland has never been repacked. The compressor is driven by spur gearing from the engine shaft, and is designed to run at half the speed of the engine. The compressor is provided with an injection valve operated by an eccentric on the crank shaft. This valve is set to open when the piston of the compressor has made a portion of its stroke, and before the pressure has reached that in the condenser. The under side of the injection valve is connected with the condensed liquor pipe between the condenser and refrigerator; the pressure therein forces a fixed quantity of the liquid ammonia into the compression cylinder, where it is rapidly vaporized, and thereby keeps the compressor at any required temperature, thickly covering it with frost if necessary.

The ammonia gas condenser is formed of U bent tubes, connected together by special junction pieces of forged steel, and so arranged that any tube can be readily replaced. The pumps for circulating the condensing water are driven by spur gearing from the crank shaft of the compressor, and they are fixed in the condenser tank, which is placed underneath the engine room floor. The refrigerators are two in number, and are multitubular in design. The shells are of steel welded, with one end welded in. The tubes are U-shaped, and are secured into hammered steel tube plates by steel screwed collars, and are so arranged that the tube plates and tubes can be withdrawn from the shells at pleasure. The liquid ammonia surrounds the tubes and the lime is circulated through the tubes by means of pumps, similar in design to the water circulation pumps. The lime pumps are fixed in the refrigerator tank, and consequently have only to raise the lime the few inches necessary to cause it to flow back to the congealing tanks.

The connecting pipes between each part of the apparatus are of seamless steel, the valves are of forged steel, and all parts of the apparatus exposed to the action of the ammonia are of steel or wrought iron, except the compression pump, which, perforce, is of cast iron. The *modus operandi* of the apparatus is now so well understood that it is not necessary to describe it in detail, and it will be sufficient to state that the working temperature of the brine is usually from 14 deg. to 11 deg. Fah.

The steam is furnished by a boiler which was put



IMPROVED AMMONIA ICE-MAKING MACHINE.

down some years ago to drive an ice-making machine on another principle, and was not supplied by the Pulsometer Engineering Company, and no test has been made of the quantity of water evaporated per pound of fuel. The proprietor writes: "You may say the cost of labor for making twenty-five tons of ice would not be more than 1s. 6d. per ton, which, of course, does not include the cost of the man to see to the selling of it; and the cost of fuel is less than 1s. per ton of ice produced." The apparatus has been running since June, which is perhaps too short a time over which to take the cost of ammonia, but the makers tell us they can refer to machines which have been at work for three years, during which time the expense of ammonia has not exceeded one farthing per ton of ice made.—*The Engineer.*

SIBLEY COLLEGE LECTURES.—1889-90.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

III.—RADIOPHONY.

By ALEXANDER GRAHAM BELL, of Washington, D. C.

THE lecture of Mr. Professor Bell was not written, but was delivered rapidly and in admirable language, extempore, the speaker having evidently become so perfectly familiar with the subject that he required no notes even. We are therefore unable to give the lecture in full, but will endeavor to present its principal points. The audience was composed of not only professors and students, but of many ladies and many visitors from the city, filling the new auditorium of the Christian Association, Barnes Hall, to its utmost capacity, and many going away unable to find seats. A set of the Bell radiophonic apparatus was placed upon the tables before the lecturer, which, after being used for his purposes of illustration, was presented to the university for use in the Sibley College work and in the Physical Laboratory. The lecturer expressed the hope that it might be employed in the prosecution of some of those investigations for which the university and the college are becoming famous.

The subject now termed "radiophony" was originally revealed and investigated by Professor Bell, and its first presentation was at the meeting of the American Association for Advancement of Science at Boston, in 1880, on which occasion Professor Bell gave the lecture which was the announcement of his great discoveries in this field to the world. He at that time showed for the first time that it was possible to produce variations in the intensity of a stream of radiant energy, a beam of sunlight, that should produce in turn variations in the flow of energy in other substances than the ether, resulting in the production of sounds which could be heard and interpreted by the telephone. Those of our readers who are especially interested in this wonderfully attractive subject will find the lecture reported in the SCIENTIFIC AMERICAN SUPPLEMENT, No. 246, Sept. 18, 1880. Various experimental devices were illustrated in subsequent numbers.

Since that date the work has been taken up by English, French, and German physicists and has developed many interesting phases and led to most interesting results. In America, however, there seems to be no one engaged in its investigation at present, except its original discoverer and promulgator and his aids. This seems particularly unfortunate; but it is to be hoped that Professor Bell himself may yet find the opportunity to resume the researches interrupted by more pressing matters.

According to Mr. Bell, the first to touch upon the fundamental principles and the foundation facts of this new science or art, if it may be so called, was Professor Page, of Washington, the famous builder of the magneto-electric engine and locomotive of the earlier days of this century. He noticed that the core of an electro-magnet emitted sounds when demagnetized, and was able to produce a succession of such sounds in any relation as to time, but, of course, not with any variation of note or quality of sound. Attempts made to obtain articulate and intelligible sounds by this means were unsuccessful. Had this experiment succeeded, we should very probably have had a telephonic system before the introduction of the electro-magnetic telegraph of Morse.

In 1817 Berzelius observed a peculiar reddish brown substance deposited during the manufacture of sulphuric acid. In the blowpipe flame it emitted the smell of tellurium, and assuming that it was that, he attempted to separate it from the substances with which it was in combination. He did not succeed, and after extracting all the known substances there still remained a metal, which he called selenium, on account of its resemblance to tellurium. They differed in one important particular. Tellurium was a good conductor of electricity while selenium was a very poor one, except when in a liquid state, or after it had been cooled slowly from a liquid state. The resistance of an inch of selenium wire was found to be 1,400 megohms, or equal to that of a telegraph wire from the earth to the sun. Willoughby Smith discovered that its resistance was extremely variable, and seemed to be greater at night than during the day. The suggestion that light affected its resistance led to experiments in this direction, which showed such to be the case. It then occurred to Bell to put a piece of this metal in circuit with a telephone. Varying the intensity of light would vary the resistance of the circuit, and thus produce a sound in the telephone. By making these changes of light intermittent, a musical tone could be produced, or by making changes corresponding to the Morse alphabet, letters and words could be transmitted. The high resistance of the selenium made it necessary to adopt a form of cell which should contain quite an amount of this metal, but at the same time have considerable conductivity.

A number of small strips of iron were laid side by side, but without touching. Alternate strips were connected to the same terminals of the cell. The melted selenium was poured over all, and was thus put in "multiple arc" between the two sets of strips. By this means the resistance was reduced to a measurable quantity. This cell was put at the focus of a parabolic mirror, and a slight difference in the amount of light which entered the mirror changed the resistance of the cell, and thus produced a sound in the telephone. The sending instrument consisted essentially of a silvered sheet of mica. When waves of sound struck the back of this mirror, its surface changed shape, and varied the amount of light reflected by it. These devices proved unsatisfactory. Mr. Bell therefore substituted for the above described sending instrument a revolving wheel with a large number of holes in it, to "chop up" the light. The light which has been made intermittent by the action of the wheel is focused directly on the selenium cell before described. By cutting off the light by some opaque substance at proper intervals, the Morse alphabet could be sent, and Bell succeeded in transmitting to a distance of one and one quarter miles in this way. The apparent motion of the sun interferes with this method to a considerable extent.

In cutting off the ray, a sheet of ebonite was accidentally used. It did not cut off the sound. Further experiment showed that the heat rays, instead of the light waves, produced the effect.

Bell put the ebonite to his ear, not using the telephone nor selenium cell, and heard sounds. He found finally that nearly all solid substances, when subjected to the action of an intermittent ray, emit sound. All gases, excepting dry air, have the same property. Bell went so far as to allow the beam of light to pass directly into his own ear, and he heard sounds. Soot was found to be the most sensitive substance, and this is the material now used in the instrument.

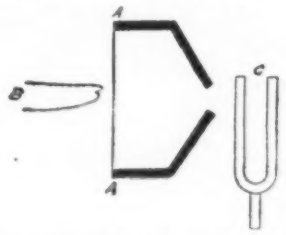
Perhaps the most interesting and promising direction of development of this subject, under the supervision and by the fertile mind of Professor Bell, is that in which the spectrophone is now being employed. The intermittent ray is passed through a prism, and the spectrum thus formed is thrown on the receiver, which emits sounds, as it meets the transmitted energy in higher or lower intensity. The visible portion of any spectrum being thus explored, it is found that the radiophone gives precisely the same indication as the spectroscope, and thus its value for other work is proved.

But there are rays outside the visible spectrum which cannot be observed through the spectroscope, and these are the rays which the spectrophone is capable of detecting. The instrument is thus an apparatus of research of great value, and gives the map of the exterior spectrum with great convenience and accuracy. The dark lines or spaces of reduced energy are detected readily, and the map of the invisible spectrum is thus reproduced by this new method.

Whether this will ever supersede the eye and the thermopile in the analysis of the whole spectrum, may be doubted; but its convenience in use, and the facility with which a good ear takes up the sounds and replaces the eye as a means of investigation, is such that it is not improbable that it may ultimately find special and exceedingly important applications. The map of the ultra-red spectrum has been already very completely explored by Professor Bell and his associates in this entrancing field of scientific research.

SOUND

THE majority of people seem content to accept the theory that sound is a wave motion of the air as proved beyond all doubt; but the mathematical theory of sound requires the introduction of the laws of heat, etc., as well as mechanics. To account for the velocity of sound in air, I send you an account of an experiment on the "nature of sound" which I made some years back. The diagram represents a section of a resonator. A A is the back of the resonator, and this back is made of thin metal, the other portion being much stronger.



When the tuning fork, C, is set in vibration, the thin metal back shakes about with the motion of the tuning fork by the action of the inclosed air, but very little sound is heard. When, however, the back is prevented from shaking by holding the finger or anything else against it, at B, a very loud sound is obtained. In this last case the inclosed air does not move anything like as much as in the previous case, but instead it is condensed and expanded by the vibration of the tuning fork. The loudness of the sound in this experiment is therefore in proportion to the amount of the condensation and expansion, and not to the degree of motion of the air which is supposed by the wave theory.

Again, if a good bell is struck with a weight of 1 lb. falling 1 ft., it can be heard at a distance of 1,024 ft. or more, the sound, therefore, will move a sphere of air 2,048 ft. diam., and your mathematical readers will doubtless be able to calculate what distance the air moves at the end of one second of time. It cannot be very great, for the weight of air to be moved is enormous, and the distance the bell moves is very small.—*J. Sutcliffe, in Eng. Mechanic.*

ASTRONOMY—NOTICES FROM LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

Return of Lexell's Comet.

THE news of a remarkable and extremely important discovery in cometary astronomy, made by Mr. S. C. Chandler—so well known as a mathematician and astronomer—has just been received. Mr. Chandler has just completed a preliminary examination into certain peculiarities of the orbit of the comet discovered in July last by Mr. Brooks, and which is still under observation.

This comet has been found to revolve in an elliptical orbit about the sun in seven years. It has attracted particular attention through the discovery, at the Lick Observatory, of the remarkable companion comets that attend it in its journey through space.

Before speaking of Mr. Chandler's discovery, it will be necessary for us to go back, in time, over one hundred years, to the date of the discovery of Lexell's comet, in 1770. Upon the computation of the orbit of this comet, Lexell found it to be revolving about the sun in a period of five and one-half years. This was considered remarkable, for the comet was visible to the naked eye, and, therefore, ought to have been seen at some of its former returns. But it had never been seen before—nor, indeed, since.

Lexell found that the aphelion of this comet was very close to Jupiter, and that it had made a very close approach to that planet in 1767. He also found that, previous to 1767, the comet had moved in an orbit whose perihelion was near Jupiter, and its distance, therefore, so great that it could not be seen from the earth.

At this near approach to Jupiter in 1767, the planet's attraction on the comet was three times as great as the sun, and the comet, therefore, remained in the vicinity of Jupiter many months, its orbit becoming completely changed, so that when it finally was freed from the overpowering influence of the planet, it was thrown into a much smaller orbit, in which it would make a revolution in five and one-half years. In this small orbit it approached very near the earth, and was visible to the naked eye.

At its nearest approach to the earth in 1770 it was less than one-half million miles distant. So close was the approach, indeed, that La Place computed that if the comet had any considerable mass, it would have seriously disturbed the motion of the earth in its orbit, and if the mass had been equal to that of the earth, it would have shortened the length of our year by something like three hours. From the fact that no sensible disturbance was experienced from the proximity of the comet, La Place concluded that its mass was certainly less than the one three-thousandth part of the mass of the earth, or less than one-fortieth of the mass of our moon. It was, doubtless, vastly smaller than that.

In 1779 the comet made a still closer approach to Jupiter, and at that time the attraction on the planet was over two hundred times as great as that of the sun, and the orbit was again changed, the perihelion becoming so great that the comet could not be seen from the earth. Burckhardt, who verified Lexell's calculations, found that before the comet came under the influence of Jupiter in 1779, its perihelion distance was probably 5·08, while that of the small orbit of 1770 was 0·67, and after the disturbance through its proximity to Jupiter, in 1779, its perihelion distance probably became 3·33, the distance of the earth from the sun being assumed unity. This body, because of its never having been seen since 1770, has been called the lost comet, and it has stood as the most remarkable example that we have of planetary influence in disturbing the motions of comets.

We will now return to Mr. Chandler's investigations. He found that Brooks' comet must have made a remarkably close approach to Jupiter in 1886, and that the attraction of the planet then threw the comet into its present orbit, whatever may have been its path previous to that time. This led him to suspect the identity of this comet with the famous Lexell comet of 1770, and he, therefore, attacked the problem with renewed interest. He found that, previous to the encounter with Jupiter in 1886, the Brooks comet was moving in an entirely different orbit to that which it now moves in. The periodic time in this former orbit was twenty-seven years, and its aphelion lay outside of Saturn's orbit, and the perihelion where the present aphelion is.

Mr. Chandler, in speaking of the motion of the comet before the disturbance of 1886, says: "Several months before reaching its perihelion, it passed, near the beginning of 1886, into the sphere of Jupiter's attraction, and was deflected into a hyperbolic path about the planet, remaining for more than eight months under its control—the disturbing action of the sun during most of the interval being insignificant. The eccentricity of the hyperbola was but slightly in excess of unity, so that the comet narrowly escaped being drawn into a closed orbit as a satellite of Jupiter. A slight diminution of the initial velocity relatively to Jupiter would have thrown it into an elliptic orbit about the planet."

Mr. Chandler also says that, at the close approach to Jupiter in 1886, the comet passed a little outside of the orbit of the third satellite, and that it is not impossible that the unequal attraction of Jupiter and his satellite system may have caused a disruption of the cometary matter such as would produce the companions that have been discovered attending it, and that these small bodies may owe their existence to the opposing attractions of Jupiter and his satellites, in 1886.

What have been the changes that this comet has undergone since 1770 through the repeated disturbances by Jupiter, it is not possible to tell at present. However, the comet is now, at least, free from the disturbing action of that planet; but this will not continue indefinitely, as it will again encounter Jupiter in 1921, under nearly the same conditions as in 1886, and its orbit will again suffer a complete change, the comet, perhaps, once more being thrown into an orbit whose perihelion distance will be so great that it will again be lost to observers, with perhaps as long a period of invisibility as it has suffered since 1770, to reappear again some time in the future, through the attractions of Jupiter, if, indeed, it can maintain its integrity as a single body under the enormous stresses to which it has been, and may again be, subjected. However this may be, there is very little doubt that Mr. Chandler has been the first to point out one of the most remarkable of all cometary histories, and that his discovery is of the first importance. E. E. BARNARD.

Mt. Hamilton, December 5, 1889.

The Lunar Crater and Rill—Hyginus.

I have asked Mr. Barnard to make positive enlargements on glass of one of our best moon negatives. A negative of August 14, 1888 (made by Mr. Burnham), has thus been enlarged two times, and shows the moon, therefore, exactly as it would appear in the principal focus of a telescope 1140 inches, or 95 feet, long.* I find

* *Sidereal Messenger.*

* The focus of our photographic lens is 570·2 inches.

that I can use on this positive an eye piece of one inch equivalent focus as a magnifier. That is, it is practicable to examine the lunar surface under perfect conditions of definition and illumination, and under a magnifying power of more than 1100 diameters, or, as if viewed by the naked eye, at a distance of 217 miles or so. This can be done whenever one pleases, and as long as one pleases.

As a test of the excellence of definition, I may mention a discovery which I have made on Mr. Barnard's enlargement. It is well known that Maedler (and others) have mapped the walls of the Hyginus rill crossing the floor of the Hyginus crater. So far as I know, this has only been once seen. The observation is a delicate one, and could only be made when the sun is shining nearly in the direction of the preceding branch of the rill The walls inside the crater are hardly more than 2,000 yards apart, and their bright tops are not more than 200 to 220 yards wide. Yet they are plainly and obviously visible in this enlargement.

From this single example (among many others which could be given), it is possible to form a judgment of the results which a competent selenographer could draw from a series of our moon negatives. I have no hesitation in saying that a two or three years' study of such a series would produce greater results than all the previous work of observers in this line, great as these results have been. Unfortunately, the limited force at the Lick Observatory will not permit us to undertake anything more than the production of the negatives themselves. By depositing sets of these at certain scientific centers, they will be sure, sooner or later, to be studied by competent observers.—*Abstract by E. S. Holden.*

INSTANTANEOUS PHOTOGRAPHY.

SCARCELY a week passes in which we do not receive a few interesting photographs from our readers. We regret that we cannot reproduce or analyze all that are sent to us. We shall be content at present to reproduce two excellent ones. One of these (Fig. 1) was sent to us by Mr. Otto, of Marseilles. It was obtained with the aid of Mr. Jaulin, the able preparator of the Faculty of Sciences, and represents a number of youngsters taking a cold bath in the port. The photograph is very sharply defined, and the composition as a whole is very happy.

The other photograph (Fig. 2) is due to Mr. G. Berteaux. It represents a young man leaping over the back of a wooden bench upon whose seat he was standing. The photograph is interesting by the attitude of the leaper. His legs are bent and his arms are extended and form a balance pole, as it were, that uplifts the body.—*La Nature.*

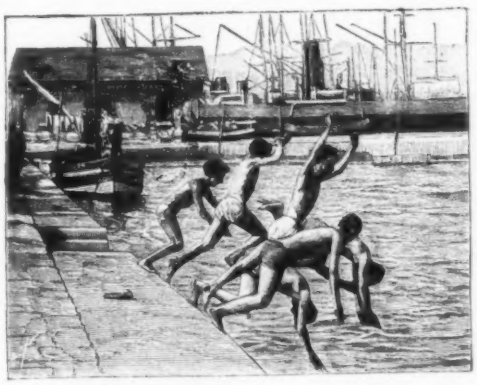


FIG. 1.—INSTANTANEOUS PHOTOGRAPH OF BOYS DIVING.

FIG. 2.—INSTANTANEOUS PHOTOGRAPH OF A MAN LEAPING OVER A BENCH.

PHOTO-LITHOGRAPHY AND THE NEW ALBERT PHOTO-LITHOGRAPHIC TRANSFER PAPER.

By HERMANN E. GUNTHER.

THE following is a detailed description of the photo-lithographic process as it is in practical use in the most eminent printing establishments in Austria and Germany. I have very often had opportunity of seeing how successfully it is worked, and can therefore state that the firm of E. Jaffe & A. Albert, of Vienna, deserves much credit for having introduced the new transfer, which is a boon to all photo-lithographic workers.

The bichromate bath consists of:

Water	1,000 c.c.
Bichromate of potash.....	50 grammes.

To this solution caustic ammonia is added until the reddish color of the bath turns to a light yellow color; an excess of ammonia does no harm. The temperature of the bichromate bath should be about 66° F. It is filtered into a flat dish of sufficient size, and the paper, with the prepared surface up, entirely immersed, and allowed to remain in the bath until it is quite soft. This is of importance, for, if it is not soaked long enough, also if the temperature of the bath is below 66° F., the bichromate solution will not enter sufficiently into the prepared film, and consequently, at the subsequent inking up of the copies, the color will adhere but badly to the exposed parts, especially to the broader lines and surfaces of the picture.

If sufficiently soaked, the paper is removed, held over the dish so that the fluid flows off only at one of the lower corners, and allowed to drain until the liquid only drops. Then the two corners of the paper, which have been held, are given to a second person, who now holds the sheet over a plate glass a little larger than the paper. This plate glass must previously be well cleaned, then rubbed in with talc powder, and the surplus of the latter dusted off with a broad soft brush. On this glass plate the sheet is placed with its lower edge of the prepared surface, and smoothed down by means of a soft cloth. During this operation the person assisting holds fast the corners of the paper until the mounting is finished, and only gives slowly way to the pressure of the smoothing down.

If too much of the talc powder has been dusted off the plate glass, it may happen that the paper, after drying, partly adheres to the glass, and even tears here and there; it is therefore necessary that a certain amount of the talc powder remains on the plate, and better a little too much than too little. Should the paper, after entirely drying, still adhere to some parts of the glass, then the latter has been badly cleaned.

Care should also be taken that in smoothing down the paper no air bubbles arise between the glass and the paper, since they will appear on the dry paper in the form of matt spots, which will interfere in the case of fine work. As soon as the sheet lies quite flat on the glass, the back of it is well rubbed with a soft cloth, applying thereby a certain degree of pressure to suck up the fluid on the back of the paper, and also to squeeze out the bichromate bath between the paper and the glass, and by this means to accelerate the drying process.

The glass plate, together with the paper on it, is now placed in a darkened, not too warm room, and dried spontaneously; after six to twelve hours it will be dried. This may be ascertained by touching the back of the sheet, and by the paper easily stripping off.

After stripping, the paper shows a beautiful, high gloss; it is now ready for copying, and must, of course, be kept in the dark. The sensitized paper should be used up within twenty-four hours, because, if it is kept for a longer time, it is more difficult to work. In the stripped state the paper should be kept in a not too dry place, for if it is too dry, or even brittle, no sharp copies are to be obtained with it, since it does not join closely to the negative. Besides, it is important to preserve in the paper a certain degree of flexibility, because it will then be possible to open one-half of the printing frame in order to control the progress of the printing process, without fear of obtaining a doubled print. Should it, however, occur that the paper is too brittle, it may be placed between slightly moistened blotting paper, but care must be taken that the transfer paper does not become too damp.

In printing, it is not necessary to use a photometer, since, as we have mentioned above, it is possible to watch the progress by opening one side of the back of the frame, provided that the paper is sufficiently smooth. The print should have a brown tone and appear in visible relief from the ground. Over-printing is very injurious, because the lines and points of the image become thereby broader, and the development of the copy becomes difficult. If, however, it is underprinted, the color does not adhere to the image in development, or, at least, it adheres only to the vigorous parts of the print.

Care should also be taken that the backs in the printing frame are not damp, because this is obnoxious to the sharpness of the print. Sometimes it will happen, especially in the case of copies from densely drawn originals, and in the case of copper engravings, that certain parts of the negative will print too quickly; parts of this kind are varnished on the back with carmine, as it is usually done in the case of negatives with half tones.

The inking of the transfer may be carried on in different manners, but in all cases it is essential to lay on a light color tone evenly over the whole of the copy. This may be done by means of a sponge or a rag, as well as with a velvet roller; the main point is always the result. The manipulations are as follows: The smooth face of a lithographic stone is, by means of an ordinary lithographic leather roller, inked up with good transfer ink, and the velvet roller, which perhaps serves the purpose best, carefully charged with a thin coating of the ink; then the copy, which has been placed on an even, smooth surface, is inked up with the velvet roller until it is evenly covered with a middle gray tone. The vigorous parts of the image should still be visible through the color, otherwise too much ink has been applied. When the transfer is successfully inked up, it is placed in clean, cold water, but care should be taken that no air bubbles adhere to the copy, in the water, and that the back of the paper remains completely covered with the water. After ten to fifteen minutes the transfer is removed, the water allowed to drain, the copy laid once more with its back on the smooth plate, and the water squeezed out from the film side by means of fine tissue paper, which is done best by rolling over it with an old clean lithographic roller, avoiding, however, carefully the formation of wrinkles, because, otherwise, the film will probably be damaged. The moistened transfer is now once more inked up with the velvet roller charged with color. If, after some rolling, the image comes out quite distinctly, the paper, at the same time, being clear of the yellow color produced by the bichromate bath, it is only necessary to wash off with a clean, very fine, and soft sponge moistened with water the color which still adheres to the unexposed parts of the impression. If, however, the transfer, after being inked up, appears still yellow, it must be placed, before the application of the sponge, once more in the water, and the inking up with the velvet roller must be repeated.

The ready developed transfers are placed between dry, clean, and perfectly smooth blotting paper, and by gentle pressure freed from the still adhering water. Then they are fastened by means of drawing pins on a board, and dried spontaneously on a slightly warmed place free from dust.

The dry copy is placed between damp blotting paper. In the case of grained or stippled impressions, tissue paper must be used instead of the ordinary blotting paper.

In pulling through the press for the first time, only a slight pressure should be applied, it being increased at each stroke, as usually the transfer is several times wetted with water. After the last pulling through, the transfer is removed without again being wetted; if there is any difficulty in doing so, the stone may be taken out of the press, and placed for a short time in a cold room, or the transfer may be dried spontaneously. In both cases the removing of the transfer is facilitated.

The "rubbing in" or intensifying of the image on the stone is done as usual, but in the case of very fine drawings, grained or stippled images, a very slow procedure will be necessary. The sponge which is used in intensifying should contain only a small quantity of the color.

The etching may be done in the ordinary manner with slightly acid gum water; in the case of fine drawings, however, it is recommended to apply a "sharp or high etching" bath, it offering also otherwise some advantages.

For this purpose the transfer is dusted in at first with resin powder, then with talc powder, and the excessive powder carefully removed with a pad of cotton. Then two narrow long strips of wood, about one-eighth of an inch thick, are placed on the two longitudinal edges of the stone, clear of the impression, and fastened at one end in any convenient way. Then a wooden lath, about three inches wide, 1½ inches thick, and a little longer than the stone is wide, is taken, covered with cloth, and moistened with sulphuric ether; it is then placed on the two wooden strips, at the end that has been fastened to the stone, and slowly pulled over the strips at full length of the stone. It is sufficient to go once over the stone in the manner described in order to melt the resin powder, together with the color, by means of the ether vapors. Then the stone is etched for about one minute with the gum etching bath, which should be strong enough, so that it slightly scums if poured on the stone. The stone is then ready to be printed from.

With the same paper, transfers can also be made on zinc to produce relief blocks, and, indeed, it is used for this purpose by many large establishments.—*Photographic News.*

ACUTE COLDS: WHY AND HOW THEY SHOULD BE TREATED.

By C. H. STOWELL, M.D., Washington, D. C.

AMONG the diseases that people believe must be endured, acute colds stand in the foremost rank. It is understood that no ill effects follow their neglect, and no remedies give relief from their discomfort. It is equally true that the older materia medica brings to us but little hope of success outside of well-known household remedies. But now that the structures and functions of the nasal passages are so well known, and the therapeutics of some of the newer drugs so clearly demonstrated, there is no excuse for such neglect. To neglect a cold is to give an invitation to both annoying and serious affections, while to ask for relief is to obtain it.

It is only necessary to recall the exposed situation of the mucous lining of the upper air passages to fully appreciate the constantly recurring danger of exciting inflammatory changes. Let this membrane once become the seat of such changes, and it becomes more and more susceptible to exciting causes, until the most trivial exposures are sufficient to arouse old troubles. Resolution after each fresh attack is less and less complete, until finally there is developed a chronic catarrh.

As colds increase in frequency, so are they likely to increase in gravity. The inflammatory process extends farther down the continuous mucous lining of the air passages, until the larynx, the trachea, the bronchi, and even the deep lung structures may become involved.

So eminent an author as Bosworth says: "The question is often put to the physician whether a catarrh will lead to the eventual development of lung disorders; and it seems to me that the answer should be, It may and it often does." He also states that this may occur not simply as a result of the extension of the inflammatory process, as indicated above, but that the presence of the catarrhal inflammation is a prominent factor in inducing some of the graver affections of the lungs.

But there are other reasons why acute inflammations of the nasal passages should receive prompt attention. Viewed as a prophylactic, the nose has at least three important functions to perform: To warm, to moisten, and to filter the inspired air. Many experiments have been made to prove the first of these functions. Aschenbrandt, of Wurzburg, and Greville have shown that if the inspired air enters one nostril at from 46·4° to 53·6° F., it will pass out of the opposite side of the nose, without having entered the lungs, at the uniform temperature of 86° F.

Although these figures must represent the fullest capacity of the warming power of the nose, yet all writers agree that to warm the air is no mean part of the physiology of the nasal mucous membrane. Kayser corroborated the results of Aschenbrandt, and showed, in addition, that when cold air is inspired there is a marked increase in the blood supply to the turbinated bodies, thus greatly increasing their heating power.

A study of the oral cavity shows that its straight and large opening affords but little opportunity for the inspired air to come in close contact with its warm lining

—certainly but very little as compared with the smaller and tortuous passages above. Recent observations of Bloch show that in oral breathing the air is warmed very little, if any. It is evident that if air of a low temperature be brought in contact with the lower respiratory passages, inflammatory processes may be induced—indeed, would be likely to be induced.

Physiologists state that at least a pint of serum is poured out by the venous sinuses of the nose each twenty-four hours. The inspired air, passing over the nasal mucous membrane, takes up this moisture and enters the bronchi in a state of saturation; therefore it will not take any moisture from the mucous lining of the bronchi. But the dry throat, following so soon after oral respiration, proves that in the mouth there is no provision for supplying sufficient moisture. The membranes soon become dry, and the air passes to the lungs, taking moisture from the bronchial mucous membrane. Deprived of its normal watery constituents, the normal mucus of the bronchi becomes thick and a source of irritation.

As a filtering agent, the nose not only protects the parts below from the irritating qualities of particles of matter, as found in dust and smoke, but to those who believe in the mischievous power of germs it must also act as a germ filter. The tortuous structures over which the air must pass on its way through the nose make it altogether probable that all parts of the current of inspired air come in immediate contact with the nasal mucous membrane. It must follow that vast numbers of germs will adhere to this membrane. These germs may be those ever present in all inspired air, or those that may give rise to the gravest forms of disease.

But what is the nature of this nasal membrane? A highly vascular structure, crowded with mucous glands and held to the parts beneath by connective tissue.

To understand the full force of this answer, it is necessary to recall the observations of Metschnikoff on the power of certain amœboid cells of the body. In his address before the alumni of Bellevue Hospital, reviewing the work of Metschnikoff and others, Osler shows how it is altogether probable that there are certain cells in the body—as the white blood corpuscles, mucous corpuscles, both free and fixed connective tissue cells—that have the power of taking within them, by means of their amœboid movements, certain germs. They have the power, also, of destroying or digesting these germs.

In the nasal passages are just those conditions necessary for one of the best battle grounds so vividly described by Osler and others. On the one hand it is the narrow entrance, the gateway, to a great field beyond. The air enters, loaded with the necessary and also with the useless and injurious.

On the other hand, notice how nature has provided for the defense of this point of attack; a tortuous passage, so that the current of air cannot pass below without first touching its warm and moist lining. In this lining are the ever-watchful defenders of Metschnikoff, congregated here "to utterly destroy the army of invading germs." Here, then, is continuously waged one of the great battles of modern biology.

Dr. Roughton, of London, has called attention to this "screening action" of the nose. He believes that it greatly diminishes the prevalence of phthisis. Viewed in this light, we are justified in accepting the new nomenclature, and hereafter speak of the nose as the "modern Pasteur filter." But this germ filter can be easily converted into a germ producer. A layer of dry or thick mucus forms a complete barrier between the friendly phagocytes and the invading enemy.

From what has been said, the following conclusions can be drawn:

1. The nose should be kept clean.
2. All obstructions to nasal respiration should be removed.
3. Mouth breathers invite diseases of the throat and lungs.
4. Mouth breathers are more likely to have certain of the diseases caused by the entrance of germs in the body.

If the nose plays so important a part, how can it be kept in a healthy condition? By promptly treating acute attacks. If the patient can be seen in the early stage, he should have at once a hot foot bath and a bowl of hot lemonade. He should then be placed in bed and covered with blankets until copious perspiration is produced. If seen at a little later stage, and the fever seems excessive and the whole system affected, then there are two marked remedies at our command—aconite and belladonna.

The tincture of aconite is best given in small doses, half a drop once every half hour for a few hours, until its physiological action is apparent. If the discharge from the nose be thin, or if the throat be involved, then small and frequently repeated doses of the tincture of belladonna will give marked relief. A brisk cathartic is often indicated and generally very desirable.

In the beginning of the attack the nasal mucous membrane is likely to be dry and swollen, giving the sensation of the presence of a foreign body, causing sneezing and a sense of fullness. In this early stage the abortive treatment, already alluded to, can be relied upon, if local treatment be combined with it. Cocaine and antipyrine are almost specifics for this trouble. They can be used as a spray in the strength of one per cent. of the former with four per cent. of the latter. Thus:

℞	Cocaine hydrochloride	gr. ivss.
	Antipyrine	gr. xviij.
	Sodium bicarbonate	gr. v.
	Water	ʒ j.

M. Sig.: Nasal spray.

This should be sprayed thoroughly into the nares. The swollen membranes soon retract, and nasal respiration is free and easy. The spray should be repeated as often as the nares become occluded. If any nasal symptoms remain after the first twenty-four or thirty-six hours, it is better to substitute a spray with an oil for its base. Thus:

℞	Cocain. hydrochlorid	gr. ix.
	Aquæ	ʒ ss.
	Ft. solutio et adde	
	Olei petrolei	ʒ j.
	Olei eucalypti	gtt. vj.
	Olei gaultheriæ	gtt. iij.

M. Sig.: Nasal spray. Shake thoroughly before using.

This spray can be used morning and night for a few days only, or until the acute catarrhal symptoms have disappeared.

As atomizers cost money, and as they cannot be carried about readily, a powder may be substituted for both the above. Thus:

℞	Sodii bicarb	gr. ij.
	Magnesiæ carb. (levis)	gr. iij.
	Menthol	gr. j.
	Cocain. hydrochlorid	gr. iv.
	Sacch. lactis	ʒ jss.

M. Sig.: Use as snuff.

The most marked relief will follow the use of this powder, and a few applications will do much to abort the catarrhal attack. Its effects are immediate, highly agreeable to the patient, and continuous for a number of hours.

In the case of young children, where a powder or spray cannot be used to advantage, an ointment can be substituted. Thus:

℞	Cocaine hydrochloride	gr. ix.
	Anhydrated lard } aa	ʒ ss.
	Vaseline }	

M. Sig.: Ointment for the nose.

A small amount of this can be placed on the end of a feather and inserted into the nose.

A word concerning any objection that may be urged as to the use of cocaine in this manner.

1. The amount prescribed in each case is small; especially is this true of the powder. The prescription given above will last a patient for days—in fact, his acute cataarh will disappear before all the powder is used.

2. Neither the sprays nor the powder should be continued after the first few days of the attack.

3. They should not be prescribed for chronic catarrhal affections; for while it is true they give great relief in chronic hypertrophic conditions, yet the relief is but temporary, and their constant use may give most undesirable effects.

4. The physician should dispense his own powder, giving not over a drachm to each patient. If possible he should dispense the sprays as well. By so doing he will retain the power to prevent any overuse or misuse of the drug.—*N. Y. Med. Jour.*

THE SCIENTIFIC AMERICAN
Architects and Builders Edition.
$2.50 a Year. Single Copies, 25 cts.

This is a Special Edition of the SCIENTIFIC AMERICAN, issued monthly—on the first day of the month. Each number contains about forty large quarto pages, equal to about two hundred ordinary book pages, forming, practically, a large and splendid **Magazine of Architecture**, richly adorned with *elegant plates in colors* and with fine engravings, illustrating the most interesting examples of modern Architectural Construction and allied subjects.

A special feature is the presentation in each number of a variety of the latest and best plans for private residences, city and country, including those of very moderate cost as well as the more expensive. Drawings in perspective and in color are given, together with full Plans, Specifications, Costs, Bills of Estimate, and Sheets of Details.

No other building paper contains so many plans, details, and specifications regularly presented as the SCIENTIFIC AMERICAN. Hundreds of dwellings have already been erected on the various plans we have issued during the past year, and many others are in process of construction.

Architects, Builders, and Owners will find this work valuable in furnishing fresh and useful suggestions. All who contemplate building or improving homes, or erecting structures of any kind, have before them in this work an almost *endless series of the latest and best examples* from which to make selections, thus saving time and money.

Many other subjects, including Sewerage, Piping, Lighting, Warming, Ventilating, Decorating, Laying out of Grounds, etc., are illustrated. An extensive Compendium of Manufacturers' Announcements is also given, in which the most reliable and approved Building Materials, Goods, Machines, Tools, and Appliances are described and illustrated, with addresses of the makers, etc.

The fullness, richness, cheapness, and convenience of this work have won for it the **Largest Circulation** of any Architectural publication in the world.

A Catalogue of valuable books on Architecture, Building, Carpentry, Masonry, Heating, Warming, Lighting, Ventilation, and all branches of industry pertaining to the art of Building, is supplied free of charge, sent to any address.

MUNN & CO., Publishers,
361 Broadway, New York.

Building Plans and Specifications.

In connection with the publication of the BUILDING EDITION of the SCIENTIFIC AMERICAN, Messrs. Munn & Co. furnish plans and specifications for buildings of every kind, including Churches, Schools, Stores, Dwellings, Carriage Houses, Barns, etc.

In this work they are assisted by able and experienced architects. Full plans, details, and specifications for the various buildings illustrated in this paper can be supplied.

Those who contemplate building, or who wish to alter, improve, extend, or add to existing buildings, whether wings, porches, bay windows, or attic rooms, are invited to communicate with the undersigned. Our work extends to all parts of the country. Estimates, plans, and drawings promptly prepared. Terms moderate. Address

MUNN & CO., 361 BROADWAY, NEW YORK.

THE Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. ASTRONOMY.—Notices from Lick Observatory.—Prepared by members of the staff.—Return of Lexell's comet.—The lunar crater and rill—Hyginus 11972

II. BIOGRAPHY.—Emile Muller as a Ceramitist.—His many attainments as a scientist and his success in the manufacture of terra cottas, etc. 11966

III. CIVIL ENGINEERING.—The Inter-Continental Railroad.—A proposed route through Southern Mexico, Central America, and Colombia.—With map 11961
A Broadside Launch.—The first large ship ever launched broadside on 11962
The Ferry Steamer Transfer.—Device for transferring cars from the Canada Southern Railway on to the Michigan Central.—With numerous illustrations 11962

IV. MECHANICAL ENGINEERING.—New Express Engine for Italian Mediterranean Railway.—A detailed description of this locomotive, which was exhibited at the Paris exposition.—1 illustration 11959
Steam Distribution in Compound Locomotives.—A long and interesting article illustrated by many diagrams 11959
Apparatus for Registering Velocity.—Different instruments employed by mariners, railroad men, physiologists, etc.—The odograph, its use on vehicles and for registering the speed of pedestrians.—Details of the apparatus.—With numerous illustrations and diagrams 11969

V. MISCELLANEOUS.—House Moving in San Francisco.—1 illustration 11964

VI. PHYSICS.—Sibley College Lectures—Radiophony.—Report of a very interesting lecture by ALEXANDER GRAHAM BELL at the Cornell University 11972
Sound.—An experiment in the nature of sound.—With diagram. 11972

VII. PHYSIOLOGY.—The Physiological Basis of the Sense of Beauty of Form.—By ALBERT GOODMAN.—A paper read at a meeting of the Society of Architects on February 25.—A long and very interesting article 11964

VIII. MEDICINE, ETC.—Acute Colds: Why and How they Should be Treated.—By C. H. STOWELL, M.D.—A valuable article, showing the importance of attending promptly to diseases of this nature, and treating of many of the latest and most improved methods of practice 11974

IX. TECHNOLOGY.—Dangers of Boiler Scale.—With illustration 11967
Machine for Drying and Ironing Linen.—2 illustrations 11967
Brewing at the Exposition of 1889.—Treating of the various apparatus required for processes of this kind and the improvements therein 11968
Twenty-five Ton Ice Making Plant.—The ammonia compression system and plant therefor manufactured in England.—With full description and 2 illustrations 11971

A New Catalogue of Valuable Papers

Contained in SCIENTIFIC AMERICAN SUPPLEMENT during the past ten years, sent *free of charge* to any address. MUNN & CO., 361 Broadway, New York.

Useful Engineering Books

Manufacturers, Agriculturists, Chemists, Engineers, Mechanics, Builders men of leisure, and professional men, of all classes, need good books in the line of their respective callings. Our post office department permits the transmission of books through the mails at very small cost. A comprehensive catalogue of useful books by different authors, on more than fifty different subjects, has recently been published, for free circulation, at the office of this paper. Subjects classified with names of author. Persons desiring a copy have only to ask for it, and it will be mailed to them. Address,

MUNN & CO., 361 Broadway, New York.

PATENTS.

In connection with the **Scientific American**, Messrs. MUNN & Co. are solicitors of American and Foreign Patents, have had 42 years' experience, and now have the largest establishment in the world. Patents are obtained on the best terms.

A special notice is made in the **Scientific American** of all inventions patented through this Agency, with the name and residence of the Patentee. By the immense circulation thus given, public attention is directed to the merits of the new patent, and sales or introduction often easily effected.

Any person who has made a new discovery or invention can ascertain, free of charge, whether a patent can probably be obtained by writing to MUNN & Co.

We also send free of charge Book about the Patent Laws, Patents, Caveats, Trade Marks, their costs and how procured. Address

MUNN & CO.,
Broadway, New York.

Branch Office, 622 and 624 F St., Washington, D. C.

Engineers Society Univ of Mich